A SYSTEMATIC-ECOLOGICAL INVESTIGATION OF THE ACAROFAUNA OF THE FOREST FLOOR IN MAGOEBASKLOOF (SOUTH AFRICA) WITH SPECIAL REFERENCE TO THE MESOSTIGMATA (*)

by

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ABSTRACT

The physical and chemical factors which play a role in the floor of the natural evergreen montane forests and pine plantations in the Magoebaskloof are described. Descriptions of the habitats and information on population densities and distribution in space and time of the various groups of Acari are given. Lists are furnished of the most abundant Oribatei, the families of Trombidiformes, and all the Mesostigmata that were encountered. The available ecological data for the mesostigmatid species are given; the majority of the species are new to science but 76 % of them are ecologically plastic in the sense that they are not restricted to habitats covered by specific plants.

Maximum population densities of the Mesostigmata develop during either the summer or the winter, the latter being typical of the majority of the species. Information on the biomass of representative species and groups of the Acari is given. The colony sizes and dimensions which were determined for certain species with the aid of the HUGHES (1962) paired sampling technique, are recorded. The forest soil ecological data on the Acari are compared with those available on South African pasture soils.

1. INTRODUCTION

For the greater part of man's history the world of the soil was a dark and unknown one and only very recently have people become aware of the teeming millions of organisms in the soil. For example, in a slab of forest soil 5 cm high and with a surface area of one square meter, in the Megoebas-

(*) In memory of the late Prof. F. Resende.

kloof forests, the average population density of the mites (Acari) only, in July 1963, was approximately 250,000. Almost as many Collembola and other insects were probably to be found in the same soil slab and also about twice as many Nematoda, and many times this number of Protozoa and Bacteria. The earlier ignorance about the animal life in the soil is all the more surprising if it is borne in mind that a knowledge of the soil fauna is very necessary to deal with world wide problems such as soil erosion, decomposition of vegetation litter, soil fertility, soil pollution, etcetera.

Zoologists have, however, now become aware of the scope and importance of soil zoology and many important contributions to the subject have recently been published. One of the habitats which has drawn the attention of investigators right from the beginning in the field of soil zoology, is forest soils, and one of the earliest important publications on soil zoology is Bornebusch's «The Fauna of Forest Soil» (1930). In England, Europe, the Scandinavian Isles, North and South America, New Zealand, and Greenland, much information is already available on the fauna of forest soils, but in South Africa, except for the general survey of LAWRENCE (1953) very little is known about the fauna of this biotope.

The present work is therefore an attempt to try and add to our fragmentary knowledge of the zoology of the South African forest soils, with particular reference to the soil Acari.

2. METHODS AND TECHNIQUES

2.1. NOMENCLATURE

The nomenclature of the flowering plants that is being used is that of PHILLIPS (1951); for the other plant groups, those of ADAMSON (1938) and ACOCKS (1953) are used. For the mite groups of higher status than that of family, the nomenclature of BAKER & WHARTON (1959) and EVANS *et al.* (1961) are used. The nomenclature relating to the physical or chemical structure of the soil is that of BAVER (1961), and for the composition of the soil layers in profile that of LUTZ & CHANDLER (1959) is used which is also related to that of KUBIËNA (1963).

2.2. SAMPLING

In the Magoebaskloof forest, with its very rugged and uneven floor (see description of forest soil habitat section 3), randomly located samples over the whole forest will probably not be very efficient in measuring popula-

tion densities and density changes since the chances of randomization may cause a large number of sampling points chosen to bunch together in an area which is poor in food, soil water content and other requirements of the Acari.

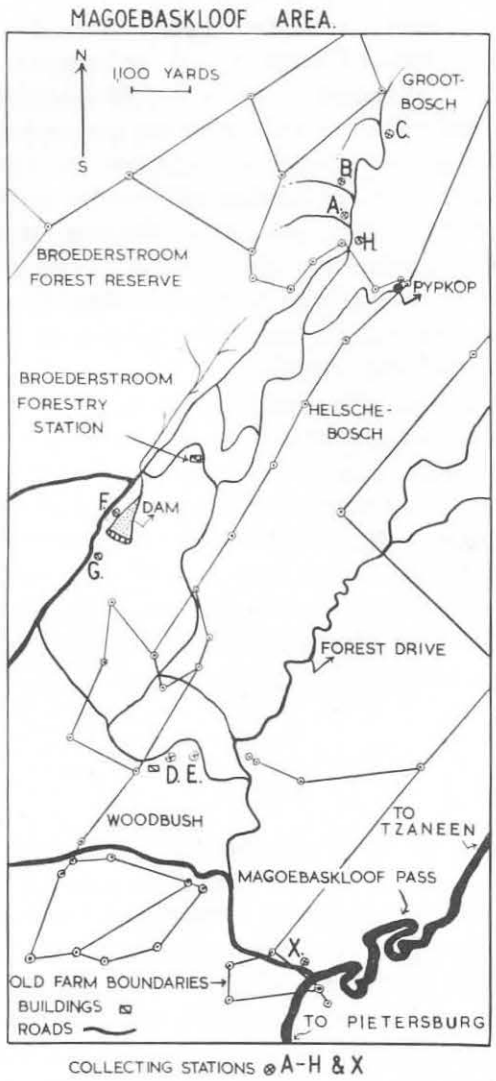

Fig. 1 — Magoebaskloof area

Certain habitat areas were therefore selected. Six such areas, from now on referred to as stations or collecting stations A-F, were selected in the indigenous forests and two in the pine plantations (fig. 1). Once a month nine

systematically placed samples were taken from every one of the indigenous forest collecting stations, for every layer separately, to give a total of 54 per month for all the indigenous forest stations together or 108 samples per year for each station and 648 samples for the six stations together per layer; sub-samples of these samples were then extracted in the laboratory with the aid of «MacFadyen improved large funnel extractors». In order to study the vertical distribution of the mites, every sample was taken in triplicate, one for every layer 0-5 cm, 5-10 cm and 10-15 cm respectively.

Although they were all selected to represent the same type of habitat, it was decided to treat the six batches of samples separately and to give the results obtained from each separately. Because of the sandyness and looseness of the soil samples, the nine samples forming every batch mixed very easily and offered no problems to sub-sampling. From every nine mixed samples a representative sample, the same volume as the original samples (251 cc), was taken and extracted.

At the end of the sampling period (one year) 20 paired samples were taken at station A, which appeared to be the best for sampling purposes, to determine the community structure of the soil Acari and the colony size of the numerically most important Mesostigmata. It was not intended to study the population changes in the pine plantations and so monthly samples were not taken there. However, 52 randomly distributed samples were taken at station G in a pine plantation and 20 randomly distributed samples at station H in another pine plantation to see whether the acarid community structure is the same as in the indigenous forests.

Size of samples

A sample size of 251 cc (8 cm diameter, 5 cm high) was decided upon because from test samples it became clear that a sample size of 251 cc was adequate to contain the most important mesostigmatid species for at least 90 out of 100 samples in the Magoebaskloof evergreen forest soils. So as to make the results comparable with those of other workers the vertical size of the samples was made 5 cm. The paired samples could not all be extracted simultaneously in the first author's laboratory and for that series of samples the extraction was done at the Institute for Zoological Research of the Potchefstroom University, using the sample sizes normally used by the Institute (vertical measurement, 5 cm and radius 3.2 cm). AUCAMP *et al.* (1964) described the structure and efficiency of the apparatus that was used at Potchefstroom.

The information on the samples can be summarized as follows:

position — selected.
number — 1,944 monthly samples sub-sampled to 216 (will be referred to as the sub-sample series in future and.
20 paired samples for indigenous forests (will be referred to as the paired sample series in future).
72 samples in pine plantations.
size — 251.4 cc and 5 cm high for monthly samples and pine samples.
161 cc for paired samples, 5 cm high.

2.3. APPARATUS

The monthly samples were taken from the soil with the aid of a soil sampler consisting of a hollow sharp-edged cylinder (internal diameter 8 cm) which can be pressed into the soil to the desired depth, and a piston for extracting the samples from the cylinder. The paired samples were taken with sampling cylinders described by AUCAMP *et al.* (1964). The samples were transported from the forests to the laboratory in plastic bags. The extraction apparatus that was used in this work for extracting the soil Acari from all samples other than the paired samples, was a battery of «MacFadyen large funnel extractors», the construction and efficiency of which are described by MACFADYEN (1961).

Because the soils that were investigated are very sandy and loose, a piece of cheese cloth (1 mm mesh) was used over the sieve to prevent the falling through of soil, and the soil was spread out over the cloth on the sieve to a maximum depth of 1 cm. At the end of every soil extraction sub-samples of the soil were investigated under a stereo-dissecting microscope to make sure that all the Acari were extracted. All samples were found to have been fully extracted at the end of 48 hours. The extracted soil fauna was collected and stored in 70 % alcohol.

During the extraction period the temperature was regulated as follows: during the first 24 hours extraction was carried out at a soil surface temperature of 26° C-30° C and during the next 24 hours at a soil surface temperature of 30° C-34° C.

2.4. SOIL WATER CONTENT DETERMINATION

For the present investigation it was not necessary to know the absolute amount of water in the soil or in what form it occurred, but only how the amount of water changed in the soil from one season of a year to another.

For this purpose the oven drying method described by LUTZ & CHANDLER (1959), DONAHUE (1961) and BAVER (1961) was found to be best suited and most practical. The water was driven off from the soil, kept in metal containers, in a drying oven at a temperature of 106° C. The temperature was regulated to 106° C to prevent the breaking up of carbonates which may be present in the soil. Soil water content was determined as

$$\frac{\text{weight of water driven off}}{\text{dry weight of soil}} \times 100$$

2.5. SOIL ORGANIC MATERIAL

Unfortunately there is no satisfactory method for determining directly the exact quantity of total organic material present in the soil. The methods available all only given approximations, the accuracy of which is, among other things, dependent on the nature of the soil. KONONOVA (1961) deals with the subject of soil organic matter in detail.

For the purposes of this investigation it was not deemed necessary to know very accurately the exact amount of organic material in the soil. An indication was only wanted of the approximate amount of organic material so that the soils could be classified and be compared with other soils. In sandy soils containing very little carbonates and bicarbonates such as, for example, the soils at the collecting stations investigated for this work, the «ignition loss method» gives a very good indication of the amount of organic material in the soil and this method was used to obtain the amounts of organic material mentioned in the description of the soil profiles. Briefly the method is as follows: the soil is dried in an oven at a temperature of 105-110° C after which it is heated in a high temperature electric oven at a temperature of about 650° C to burn off all the organic material in the soil; heating is continued until the weight of the soil is for practical purposes constant. The percentage organic material is then

$$\frac{\text{ignition loss}}{\text{dry weight of soil}} \times 100$$

2.6. TEMPERATURE, EXCHANGEABLE IONS AND pH

The exchangeable ions were measured so as to be able to compare the the soil samples were taken.

The exchangeable ions were measured so as to be able to compare the forest soils in this respect with other soils and therefore only the most impor-

tant exchangeable ions were measured, namely: calcium, magnesium, potassium and phosphorus; these ions are normally quoted in the literature.

The pH of a soil can vary considerably during the course of a year in a particular area, probably because the soil is affected by climatic conditions (LUTZ and CHANDLER 1959). To allow for possible variations in the pH of the soils at the collecting stations, 10 determinations, spread over 12 months, were made of the pH values of the upper layers at every collection station.

2.7. MINERAL PARTICLE SIZE DETERMINATION

Soil samples were prepared for mechanical analysis by digesting away the organic material with hydrogen peroxide and dissolving the carbonates away with hydrochloric acid. The Stokes law sedimentation method was used to determine the various soil fractions.

2.8. WEIGHT DETERMINATIONS

Some mite species and representative samples of the soil mite community were weighed with an «Oertling Decimicrobalance» model Z01 which is accurate to one millionth of a gram.

Before weighing them, the mites were all left in distilled water for 2 hours and were then dried for 10 minutes at 22° C in a relative humidity of 55 %. The mites were weighed at the same temperature and relative humidity in a specially constructed aluminium container.

The results must all be accepted as averages and as indications only of the approximate while they are being weighed, the mites are continually losing weight probably as a result of the evaporation of water on their body surfaces; 20 Erythraeidae mites together were found to lose as much as 1 millionth of a gram in one minute.

3. DESCRIPTION OF FOREST SOIL HABITAT

3.1. GEOGRAPHICAL LOCATION OF FORESTS

The South African evergreen forests are mainly found along the southern and western much watered coastal regions of the country. They occupy a fairly narrow strip along the southern coast line of the Cape Province, seldom extending more than 30 miles inland. In the Transkei, Natal and Transvaal,

however, the forests penetrate considerably further to the interior following the range of the Drakensberg mountain and along its terraces and foothills.

In the north eastern and northern Transvaal, evergreen forests occur in Magoebaskloof near Tzaneen and on the Zoutpansberg mountains as offshoots of the Drakensberg mountain forest. These forests, which ADAMSON (1938) classifies as montane forest, are only extensive on east and south facing slopes. The particular forests that this work is concerned with are the forests in Magoebaskloof. Magoebaskloof is a valley which lies between Tzaneen in the lowveld, 2,375 ft above sea level, and Pietersburg on the border of the plateau, 4,250 ft above sea level. The main road linking Tzaneen (23.47′ Lat. S., 30.09′ Lond. E.) with Pietersburg to the west of Tzaneen, runs through Magoebaskloof.

Because of farming practices the indigenous forests in the Magoebaskloof area have been broken up into a large number of small forests which lie mainly along the steep east to south facing slopes of the high peaks in the area, all more or less above 4,500 ft above sea level.

3.2. CLIMATE

The Government-appointed foresters at the various forestry stations in the Magoebaskloof area keep daily records of the air temperature and precipitation at their stations. The forest station nearest to the collecting stations investigated in this work is Broederstroom. It is about three miles from the most distant station, station C, and about half a mile from station F, the nearest station. The writers had access to the meteorological data kept at this station and this description of the climate of the area is based on these data and on monthly readings that were taken at the various collecting stations.

No indigenous evergreen forests were found below 4,500 ft above sea level and all the indigenous forests investigated were above 5,200 ft above sea level. The daily rainfall for the period June 1962 to August 1963 is shown in figure 2. Most of the rain falls in the summer months and very little in the winter. The month for maximum rainfall varies; it was a different month during, 1961, 1962 and 1963. The rainfall can also be torrential at certain times; fig. 2 shows, for example, that on the 11 th of December 1962, 207 mm of rain fell at Broederstroom. Snow seldom falls in the area although the 0.3 mm registered on 27 th August 1962, came down as snow.

Mists are frequent both in summer and in winter and these mists can carry enough moisture into the forests to make everything above the soil surface soaking wet. The relative humidity of the atmosphere is mostly very high but very variable even over short periods.

3.3. SELECTION OF COLLECTING STATIONS

It must be clear from the description of the forests that has been given so far that they lie on a very uneven area, on the slopes of part of a mountain range. This fact limited the choice of sampling areas very severely. Because of the nature of the investigation that was to take place on them, the sampling areas had to comply to the following selection criteria: (a) they

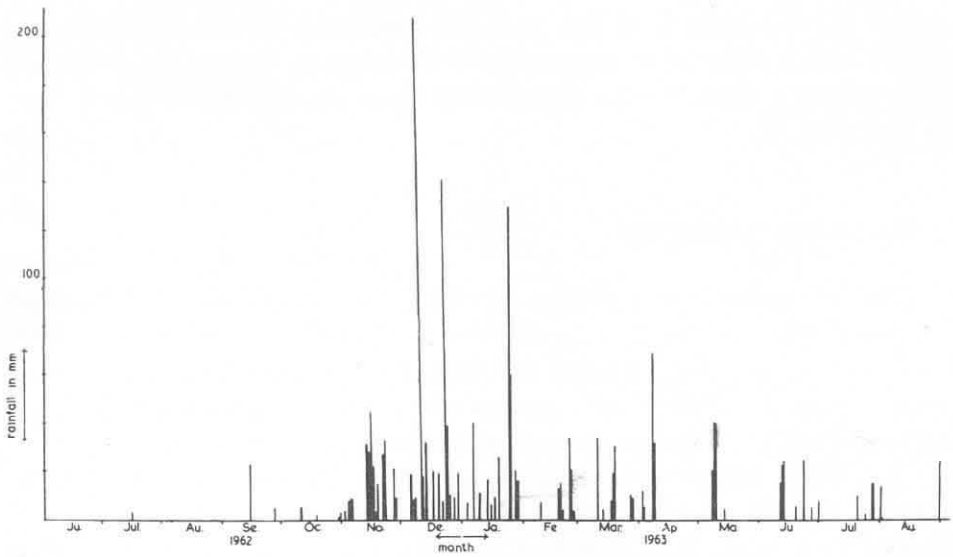

Fig. 2 — Daily rainfall. Broederstroom June 1962-August 1963

had to be big enough to allow the taking of about 200 comparable samples on the area during the experimental period, without the taking of the samples affecting the rest of the soil community; (b) the areas had to be safe from the danger of being washed away during the rain seasons; (c) the soil profile had to be constant as far as possible in the sampling area, with a well developed litter layer; (d) the sampling areas were to represent the forest in which it was selected as closely as possible; (e) test samples had to show the presence of mites in abundance.

There are no sharply defined different soil types in the area or different kinds of indigenous forest, so that possible ecological factors such as these were only briefly considered. All the collecting stations in the indigenous forest were, theferore, selected to represent the indigenous evergreen forest

as a whole. A to F on fig. 1 shows the areas where the collecting stations were selected in the indigenous forest.

The series of paired samples that will be referred to in the text later on were taken only at station A but at every one of these stations samples were taken once every month for 12 months to determine which mites are present and the possible variations in distribution and species composition of the Acari for the experimental period.

Samples were also taken in the pine plantations and only to see whether the mite community structure is the same as in the indigenous forests and whether the soil fauna is as rich as in the indigenous forests. Two collecting stations with a litter layer comparable in thickness to that of the indigenous forest collecting stations were selected and these are situated at G and H on the map (fig. 1).

3.4. FOREST VEGETATION

The indigenous forests of Magoebaskloof, for example such as Woodbush and Grootbosch, see fig. 1, are evergreen forests with few deciduous species. The forests are mixed and without any single dominant tree species. The undergrowth varies in density and species composition in accordance with the degree of shading, moisture content of the soil and other factors.

The floral constitution of the forests have already been described by ADAMSON (1938), ACOCKS (1953), LAWRENCE (1953) and others to whom these authors refer. It is therefore not intended to give another complete survey of the species composition but only to mention the numerically most important species that may be found at the various collecting stations.

Station A

The most important tree species here are:

Ochna O'Connori Phillips; *Podocarpus latifolius* R. Br.; *Ochna holstii* Engl.; *Rapanea melanophloeos* (L.) Mez.; *Syzygium cordatum* Hochst.; *Gardenia thunbergia* L.; *Cussonia spicata* Thunb.

The leaf canopy of these trees is not very dense and allows a fair amount of light penetration. The undergrowth is well developed and is mainly made up of the following:

Plectranthus sp.; *Cyperus* spp.; *Asparagus* sp.; *Senecio* spp.; and an unidentified grass.

Station B

The tree species mentioned under A are also abundant here and the following may be added:

Xymalos monospora Baill.; *Ochna arborea* Burch.

Sun penetration is the same as at A and the undergrowth contains the same species with the fern *Pelaea viridis* (Forsk.) Prantl as an extra. The density of the undergrowth is sparse compared with that at station A.

Station C

The tree species mentioned under A are also abundant here and the following may be added:

Xymalos monospora Baill.; *Podocarpus falcatus* R. Br. ex Mirb.; *Halleria lucida* L.; *Kiggelaria africana* L.; *Olea laurifolia* Lam.; *Canthium obovatum* Klotzsch.

The leaf canopy allows a large amount of sunlight to penetrate, the most of all the collection stations. Taxonomically, the undergrowth is structured in the same way as at collecting station A but it differs from A in that the undergrowth is very dense.

Station D

The numerically important tree species at collecting station D are the following:

Podocarpus latifolius R. Br.; *Podocarpus falcatus* R. Br. ex Mirb.; *Xymalos monospora* Baill.; *Lachnopylis floribunda* C. H. Smith; *Ocotea bullata* E. Mey; *Celtis kraussiana* Bernh.; *Syzygium gerrardii* (Harv.) Hochst.; *Peddiea africana* Harv.

A large amount of sunlight penetrates the leaf canopy and the undergrowth is well developed. The forest floor is well covered with a dense carpet of *Sellaginella kraussiana* A. Br., here and there it is interrupted with small stands of *Pteridium aquilinum* (L.) Kuhn, and scattered about are a few *Plectranthus* sp. and *Asparagus falcatus* L.

Station E

Except for *P. africanum* all the tree species mentioned under station D are commonly found here. The tree canopy and sunlight penetration is com-

parable to that of station A. The undergrowth has the same density and taxonomic structure as that at station A, but also includes some *Dryopteris* sp.

Station F

Important tree species:

Xymalos monospora Baill.; *Pygeum africanum* Hook., *Fagara capensis* Thunb.; *Podocarpus latifolius* R. Br.; *Cussonia spicata* Thunb.; *Kiggelaria africana* L.; *Calodendrum capense* Thunb.

The leaf canopy is fairly dense but more light penetrates through it than at station E. The density of the undergrowth is less than that at station D but better developed than that at stations A and E. Numerically important species are the following:

Selaginella kraussiana A. Br.; *Plectranthus* sp., *Senecio* spp. *Asparagus falcatus* L.

A big variety of ferns are present, for example:

Pellaea sp., *Pteridium* sp., *Dryopteris* sp., *Polystichum* sp., etcetera; *Cyathea dregei* Kze is fairly abundant.

The lichen «old man's beard» *(Usnea barbata)* is very common throughout the forests on the trunks and branches of trees. Epiphytic orchids and ferns are well represented at all the collecting stations. The lianas, creepers and climbers show a great diversity of species and are very common throughout the forests.

The forest fungi also show a great diversity of species and are very common throughout the forests, occurring in great numbers on the tree trunks, fallen logs and litter.

All the plants listed under the various stations contribute to the litter and humus layers of the soil. Therefore, the litter and humus layers in the indigenous forests are chemically a much more heterogeneous mixture than the comparable layers in the pine plantations where only two tree species and no undergrowth contribute to the soil organic matter coming from plants.

The pine plantations investigated are two mixed plantations of *Pinus patula* and *Pinus radiata* D. Donn. The plantations are about 20 years old and with a thick litter layer covering the soil. For horticultural reasons the undergrowth and lower branches of the trees are removed in these plantations. The leaf canopy is comparable to that of station A in density and as a result the same amount of light reaches the soil as at station A.

3.5. SOIL PROFILES

A vertical section through the Magoebaskloof indigenous forest soils exhibits a series of layers and if the arrangement of these layers is compared with the soil profiles described in the literature on forest soils, it will be found that the arrangement at stations A to C and E corresponds to that of

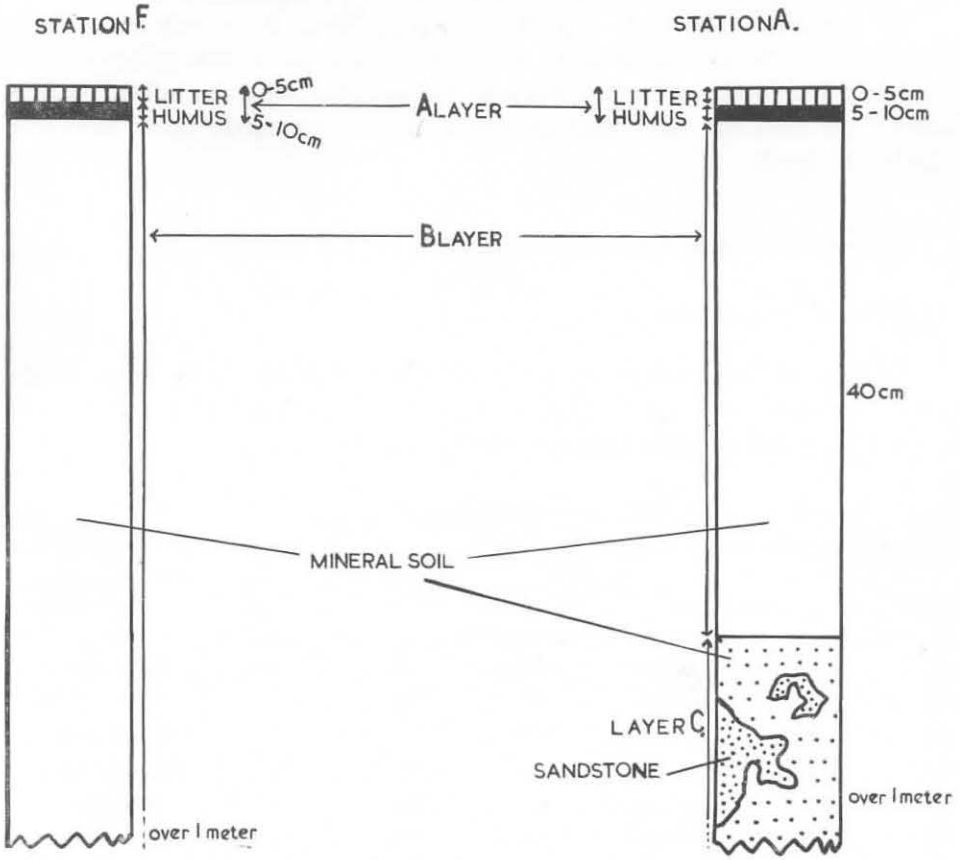

Fig. 3 — Soil profiles

a «moder» type of soil, as described, for example, by KEVAN (1962). The arrangement at station F, on the other hand, corresponds to a «mor» type of soil, as described, for example, by FENTON (1947), MURPHY (1955) and LUTZ & CHANDLER (1959). Station D is probably alluvially deposited and is structured in its own peculiar way. No «mull» soils were encountered in the forests.

At all collecting stations there is an upper layer, layer A, which is mainly made up of organic material, fresh and decayed leaves, twigs, etc. Underlying A is a second layer, layer B, which is mainly a mineral particle layer but which also has mixed with it various amounts of humus. Underlying B is a third layer, layer C, which has very little or no humus mixed with it and is mainly made up of the weathered parent mineral matter. The soil profiles of stations A and F are diagramatically represented in fig. 3.

In the pine plantation collecting stations layer A is very variable in thickness but, where the samples were taken, the litter was selected to be about 5 cm thick in order to facilitate comparisons with the other stations. Layer B at both the pine stations was a brown fine sandy-loam layer over 1 meter in depth.

3.6. PHYSICAL AND CHEMICAL PROPERTIES OF THE FOREST SOILS

Mineral particle size

Mechanical analyses were made of the indigenous forest soils at the various collecting stations to determine the textural classes of the soils. The results of these determinations are summarized in table 1.

TABLE 1 — **Textural class of soils**

Station	Layer & level		International system Sand	Silt	Clay	U.S.A system Textural class
A	B_2	0–5 cm	65 %	26 %	9 %	Sandy loam
B	B_2	0–5 cm	67	24	9	Sandy loam
C	B_2	0–5 cm	63	23	14	Sandy loam
D	B-sand,	0–5 cm	75	21	4	Loamy sand
	B-mud,	0–5 cm	30	52	18	Silt loam
E	B_2	0–5 cm	65	20	15	Sandy loam
F	B_2	0–5 cm	59	20	21	Sandy-clay-loam

All average of 5 determinations of subsamples.

Soil water content

Figure 4 shows graphically the variation of the mean soil water content for corresponding layers at all the stations.

From these figures the following facts become clear:

(a) at every collecting station the maximum amount of water held by the upper layers is much bigger than that held by the deeper lying layers in the first 15 cm of the soil; (b) in the upper 15 cm of the soil the water content tends to be low in September, rises in November and December, and then remains at a relatively high level for the next 7 months which include

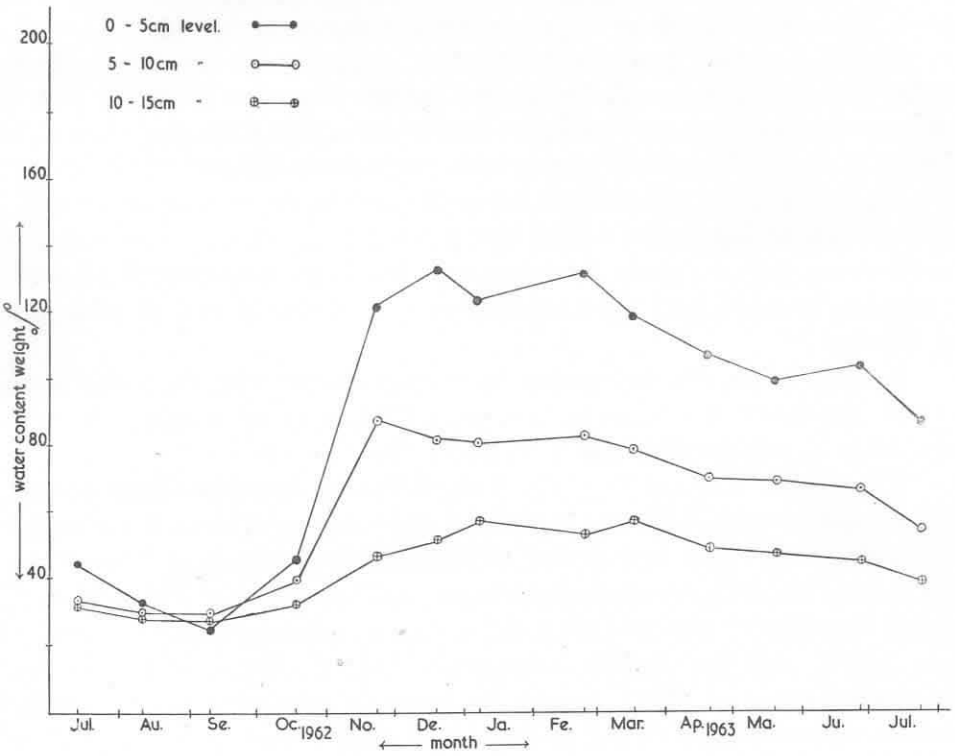

Fig. 4 — Soil water content, average for corresponding layers at all stations

the cold winter months; (c) there is a big difference in the extent of variation between the upper and lower layers, in the first 15 cm of the soil, a big variation in soil water content takes place at the 0-5 cm level as compared with a relatively much smaller variation at the 10-15 cm level. In June 1962 no rain at all fell in Magoebaskloof and in July 1962 only 3 mm, as against 96 mm in June 1963 and 35 mm in July, 1963. Different events such as these must account for the discrepancies in amount of soil water content, for example, between the two mid winter months of 1962 and 1963.

Temperature

According to ADAMSON (1938), the important facts to be measured in regard to temperature as an ecological factor are the degree of warmth at the different seasons and the amount and duration of extremes. This was done at the collecting stations at intervals of one month for a period of one year at the same times and levels as the samples for the soil Acari were taken. The results of these measurements are shown in fig. 16.

Figure 5 shows how the temperature can vary at the various levels within one day at station F. On the soil surface there is a difference of 8° C between the maximum and minimum temperatures that were read during the day; 4 ft above the soil the atmospheric temperature differed 20° C between extreme temperatures and at 15 cm below the surface the temperature remained constant. These facts make it clear that it is very necessary that all ecological temperatures that are given for forest soils should be accompanied by information as to what level the temperatures were taken at and at what time of the day.

In order to be able to compare forest temperatures with the temperatures outside the forest, for example in a grass field, a set of temperatures were also taken in a grass field (at X in figure 1).

From these data and from fig. 5 the following interesting facts emerge: (a) Compared with the lower layers, the upper layers of the soil are subject to relatively big daily and annual temperature fluctuations; at 15 cm below the surface no daily temperature changes could be detected and only small annual fluctuations; (b) the lowest soil surface temperature that was measured was 7½° C and the highest temperature 19½° C. Thus, giving a small fluctuation range of 12° C, it must be borne in mind that the coldest soil surface temperature according to figure 5 is only reached in the early hours of the morning and it is, therefore, very probable that the coldest temperature was not measured; (c) temperatures reach much bigger extremes in the grass veld than in the forest; frost was seen on the grass veld a number of times during the winter months but never in the forests.

The fact that vegetation lowers the maximum temperatures during the summer and sometimes raises the minimum temperatures during the winter has already been reported by a number of ecologists (LUTZ & CHANDLER 1959), but it is also known from the work of LI (1926) and others that the litter and humus layers covering the soil have a similar effect. However, more information is still needed on what the contribution is of each of the two factors, vegetation and litter, in natural forests. For white pine stands in southern

New Hampshire Li (1926) estimated that about 75 % of the reduction in maximum surface soil temperature was due to the forest canopy and about 25 % to the litter.

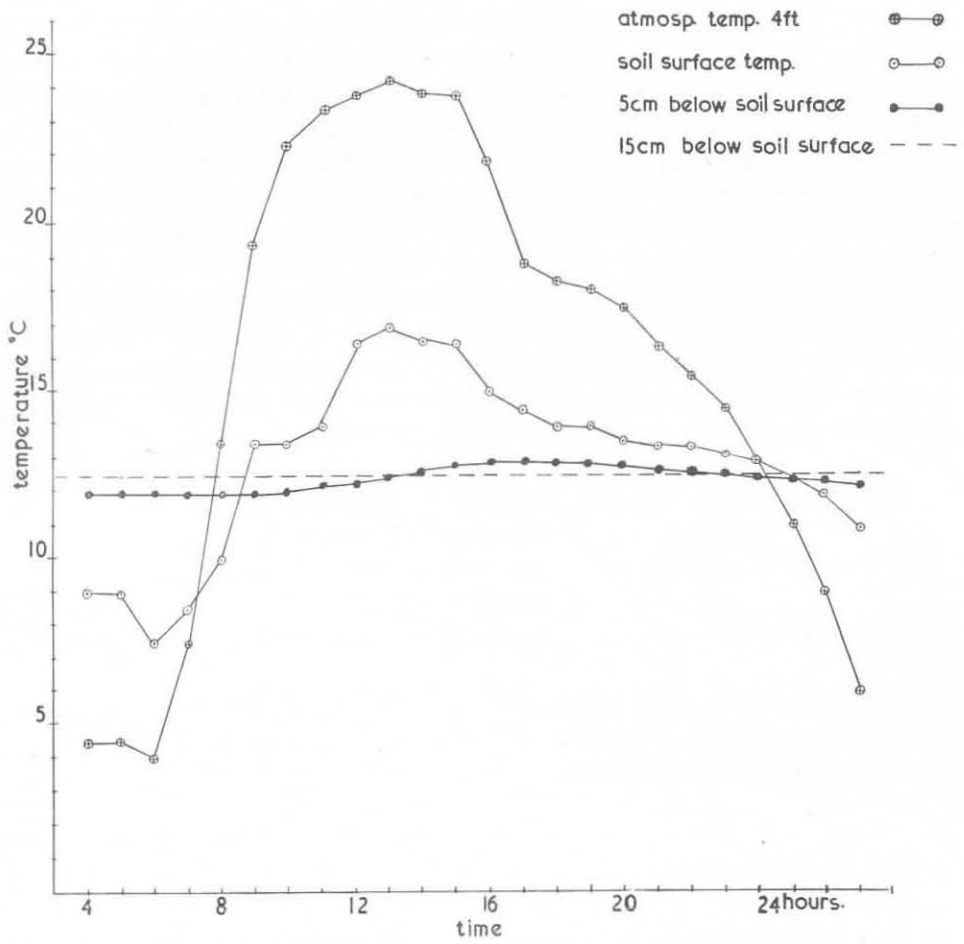

Fig. 5 — 24 Hour temperature variation, Station F

Exchangeable ions and pH

Except for the phosphates, the soils are rather poor in exchangeable ions, a fact which is generally applicable to forest soils (Lutz & Chandler 1959). The pH values varied between 3.5 and 6.2.

4. THE ACARI OF THE SOIL COMMUNITY IN MAGOEBASKLOOF FOREST SOILS

The Magoebaskloof evergreen forest soils have been found to be rich in numbers and kinds of soil organisms However, only the results of the qualitative and quantitative studies on the Acari in these soils are reported here because, for technical reasons, the results that were obtained on the other soil dwelling organisms are unreliable; the Macfadyen improved Berlese--Tullgren funnel type extractor that has been used in this investigation for extracting the soil organisms has only been sufficiently well standardized for the Acari and Collembola (MACFADYEN 1961), and the method that was used for preserving the soil extracts makes collembolan counts unreliable.

In order to facilitate the counting procedure in this work it was found necessary to group together some of the mite orders into larger units and, therefore, the following terminology of REUTER (1909) and BAKER & WHARTON (1959) is used in reporting the results of this work:

Group 1	Sarcoptiformes	(includes orders Astigmata and Cryptostigmata of EVANS *et al.* 1961).
Group 2	Trombidiformes	(includes only the order Prostigmata of EVANS *et al.* 1961).
Group 3	Mesostigmata	(order Mesostigmata of EVANS *et al.* 1961).

In this work the term «Oribatei» will be regarded as being synonymous with the term «Cryptostigmata» and the term «Acaridae» as being synonymous with the term «Astigmata».

4.1. SARCOPTIFORMES

The order Astigmata, in comparison with the other orders is, numerically speaking, an unimportant soil group and particularly does this apply to the forest soils. In the beech forest of the Netherlands, van der DRIFT (1951) found the Astigmata to be a very small group. From the work of WEIS--FOGH (1948) and HAARLOV (1960), it is clear that in the Danish soils the Astigmata as a group is also relatively unimportant; the same can be said for the Astigmata occurring in the mid European soils (BIRSFELDEN, 1949). U. S. A. soils (PEARSE, 1946) and South American soils (WILLIAMS, 1941 and di CASTRI, 1963).

The Astigmata as a group is, numerically speaking, also unimportant in the forest soils of Magoebaskloof. Because of their small numbers, they were therefore grouped with the Cryptostigmata in a single unit, the Sarcoptiformes, for counting purposes in other sample series. LAWRENCE (1953) did not find the Astigmata worth mentioning as a separate group in his studies on South African forest soils, although he does mention the Oribatei, Trombidiformes and Mesostigmata as separate groups. OLIVIER & RYKE (1967) and LOOTS & RYKE (1966) found the Astigmata to be numerically insignificant in the various types of pasture soils around Potchefstroom, South Africa.

TABLE 2 — **Some Cryptostigmata abundant in Magoebaskloof forest soils**

Family	Genus	Family	Genus
Galumnidae	*Galumna* spec. nov.	**Camisiidae**	*Nothrus* sp. 1
	Pergalumna sp.		*Nothrus* sp. 2
	Pilogalumna spec. nov. 1	**Carabodidae**	*Carabodes* sp. 1
	Pilogalumna spec. nov. 2		*Carabodes* sp. 2
	Pilizetes sp.	**Phthiracaridae**	*Phthiracarus* spec. nov.
	Trachygalumna sp.		*Steganacarus* spec. nov.
Opppiidae	*Oppia* spec. nov. 1	**Euphthiracaridae**	*Rhysotritia* spec. nov.
	Oppia spec. nov. 2		*Rhysotritia ardua*
	Oppia spec. nov. 3		*Rhysotritia minima*
	Oppia spec. nov. 4	**Oribitritiidae**	*Protoribitritia* spec. nov.
	Brachyoppia sp.	**Brachychthoniidae**	*Liochthonius* sp.
Haplozetidae	*Rostrozetes* sp. 1	**Liodidae**	*Teleioliodes* sp.
	Rostrozetes sp. 2	**Suctobelbidae**	*Suctobelba* sp.
Eremobelbidae	*Eremobelba* spec. nov. 1	**Nanhermanniidae**	*Nanhermannia* sp.
	Eremobelba spec. nov. 2	**Malaconothridae**	*Malaconothrus* spec. nov.
Ceratozetidae	*Africoribates* spec. nov. 1	**Oribatulidae**	*Scheloribates* sp.
	Africoribates spec. nov. 2	**Hermanniidae**	*Hermannia* spec. nov.
Tectocepheidae	*Tectocepheus* sp.	**Platermaeidae**	*Allodamaeus* sp.
	Tegeocranellus sp.	**Otocepheidae**	*Pseudotocepheus* spec. nov.
		Plasmobatidae	*Plasmobates* sp.

On the other hand, the Cryptostigmata was, qualitatively and quantitatively, found to be a rich group in the Magoebaskloof forest soils. Table 2 lists the species which were frequently encountered in the samples, the majority of species apparently being unknown to science. In a survey of the Oribatei *in a Themeda-Elyonurus* association pasture soil with low organic material content near Potchefstroom by LOOTS & RYKE (1966) 16 genera and 19 species were encountered, many of which were new to science. Of the genera listed in table 2 only *Scheloribates, Tectocepheus, Liochthonius, Allodamaeus* and

Oppia were also encountered by LOOTS & RYKE; the Cryptostigmata populations are, therefore, apparently quite different in the two types of habitat.

The Magoebaskloof forest soil Cryptostigmata, at the genus and species level, appear to be much different from those known in England, Europe, U. S. A. and South America.

4.2. TROMBIDIFORMES

Very little is known about the soil inhabiting Trombidiformes and, mainly because they are difficult to collect with the techniques at present available, (EVANS 1955 and EVANS *et al.* 1961) very few soil ecologists have differentiated the Trombidiformes into smaller taxonomic units in their investigations and those that have done so, usually restricted it to the family level. In this work, therefore, the Trombidiformes are also dealt with in family units.

Table 3 lists the families of the Trombidiformes that were encountered in the Magoebaskloof forest soils and compares the findings with those found by OLIVIER & RYKE (1967) and LOOTS & RYKE (1966) in a kikuyu and a *Themeda-Elyonurus* association pasture soil respectively. It is very probable that some of the families which normally occur in very low frequencies will also be found in some of the habitats in which they are not listed now, but even if such allowances are made, it is clear that both the pasture soils listed have a qualitatively richer trombidiform fauna than the forest soil and that *Themeda-Elyonurus* pasture soil harbours a wider range of families than the other two soils listed.

If population densities (dealt with in section 4.4) are also taken into consideration, certain groups of families appear to be characteristic of the different soil types; in forest soil the series of the three most abundant families, in order of abundance, is Tydeidae, Scutacaridae and Eupodidae; in the kikuyu soils and *Eragrostis* soils the series is Tydeidae, Nanorchestidae and Tarsonemidae; in *Themeda-Elyonurus* pasture soil it is Tydeidae, Tarsonemidae and Nanorchestidae. The pasture soils all appear to be related in that they have as the dominant group of families the Tydeidae, Nanorchestidae and Tarsonemidae and in doing so seem to be radically different from the forest soil in which the Scutacaridae and Eupodidae together with the Tydeidae are the dominant families (fig. 6).

A comparison of the distribution of the soil inhabiting trombidiform families in South Africa with that in other countries is at this stage perhaps premature because not enough is known to make such a comparison worthwhile.

TABLE 3 — **Trombidiformes families in Magoebaskloof forest soils and Potchefstroom pasture soils**

Family	+ means present soil Magoebaskloof forest	Potchefstroom pasture soils Kikuyu (1)	*Themeda-Elyonurus* (2)
Tydeidae	+	+	+
Scutacariade	+	+	+
Eupodidae	+	+	+
Trombidiidae	+	+	+
Rhagidiidae	+	+	+
Erythraeidae	+	+	+
Labidostommidae	+		
Cunaxidae	+	+	+
Bdellidae	+	+	+
Pseudocheylidae	+		+
Trombiculidae	+		
Smaridiidae	+		
Pyemotidae	+	+	+
Nanorchestidae	+	+	+
Tarsonemidae	+	+	+
Rhaphignathidae	+	+	+
Penthalodidae	+		
Stigmaeidae		+	+
Lordalichidae		+	+
Tetranychidae		+	+
Linotetranidae		+	+
Caligonellidae		+	+
Paratydeidae		+	+
Anystidae			+
Caeculidae			+
Eriophyidae			+
Cryptognathidae			+
Tuckerellidae			+
Tenuipalpidae			+
Cheyletidae			+

1) Olivier & Ryke (1967).
2) Loots & Ryke (1966).

However, all the families listed by Evans *et al.* (1961) as being widely distributed in European soils have been found in South African soils. The family Tydeidae appears to occur universally in big population densities also in the South African soils that have been investigated.

4.3. MESOSTIGMATA

In the world in general very little is known about the soil inhabiting Mesostigmata and the reason for this are probably because they do not attain the high numbers of the Cryptostigmata in the soils, are more difficult to collect and, in the view of EVANS *et al.* (1961), are dificult to classify.

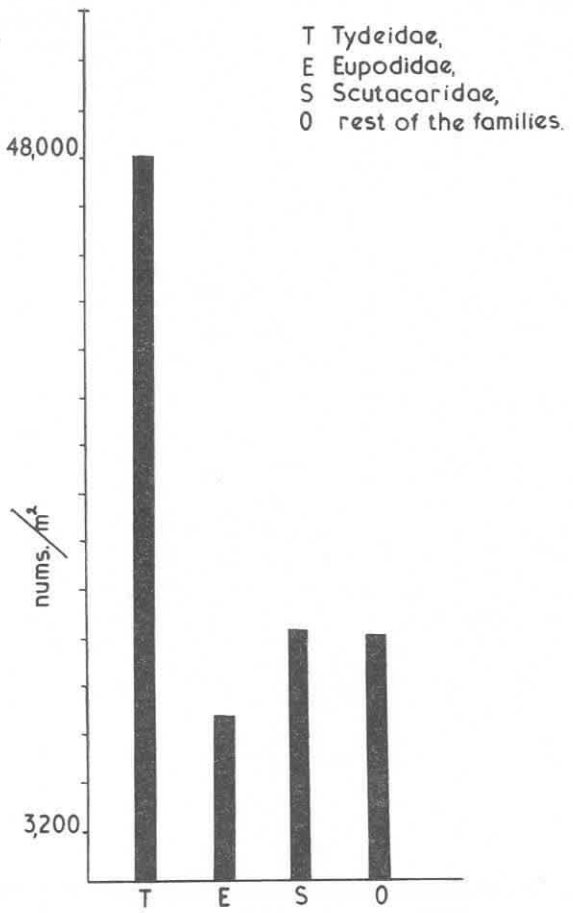

Fig. 6 — Trombidiformes, average population density of families in Magoebaskloof forest soil

Table 4 lists the Mesostigmata species that were collected in the Magoebaskloof evergreen forest soils. The following facts emerge from the list. Fifty-two species representing 32 genera and 10 families were collected. The family Rhodacaridae is dominant in regard to both the number of genera and

TABLE 4 — **Mesostigmata collected in Magoebaskloof forest soils**

Serial No.	Family	Genus	species	Maximum numbers per m² for Paired sample series	Sub sample series
M1	**Rhodacaridae**	*Gamaselliphis*	spec. nov.	1,240	2,068
M32		*Gamaselliphis*	spec. nov.	1,240	1,128
M38		*Gamaselliphis*	spec. nov.	1,550	4,136
M2		*Gamasellus*	*natalensis* Ryke 1962	2,790	1,504
M3		*Gamasellus*	spec. nov.	4,690	2,820
M4		*Gamasellus*	*nkandhlaensis* Ryke 1962	620	188
M7		*Gamasellus*	spec. nov.	8,060	4,324
M16		*Gamasellus*	spec. nov.	11,160	6,392
M34		*Gamasellus*	spec. nov.	2,790	1,128
M43		*Gamasellus*	spec. nov.	620	1,692
M45		*Gamasellus*	spec. nov.	310	2,256
M52		*Gamasellus*	spec. nov.	310	752
M5		*Gamasiphis*	spec. nov.	1,860	1,504
M15		*Gamasiphis*	spec. nov.	310	1,880
M33		*Gamasiphis*	spec. nov.	620	564
M17		*Rhodacarellus*	spec. nov.	11,470	19,140
M18		*Rhodacarus*	*rhodacaropsis* Ryke 1962	1,550	7,332
M20		*Rhodacarus*	*sublapideus* Ryke 1962	—	564
M19		*Digamasellus*	spec. nov.	—	564
M41		*Gamasellodes*	spec. nov.	—	2,444
M47		*Gamasellodes*	spec. nov.	—	—
M48		*Notogamasellus*	spec. nov.	930	752
M44 A		*Gamasellopsis*	spec. nov.	310	376
M44 B		*Gamasellopsis*	spec. nov.	—	
M8	**Aceosejidae**	*Sejus*	spec. nov.	310	376
M10		*Plesiosejus*	spec. nov.	3,100	3,948
M11		*Proctotaelaps*	spec. nov.	620	564
M14		*Lasiosejus*	spec. nov.	620	376
M27		*Asca*	*aethiopica* Ryke 1961	1,860	4,512
M37		*Asca*	spec. nov.	—	1,128
M39		*Iphidozercon*	spec. nov.	620	1,316
M26	**Laelaptidae**	*Leptolaelaps*	*elegante* Berlese 1918	1,860	1,504
M29		*Cosmolaelaps*	spec. nov.	—	1,316
M42		*Gaeolaelaps*	spec. nov.	—	376
M40		*Hypoaspis*	*speculifer* Berlese	1,550	940
M30	**Macrochelidae**	*Holotaspella*	spec. nov.	—	188
M31		*Macrocheles*	spec. nov.	310	376
M36		*Macrocheles*	spec. nov.	—	564
M53		nymphs	sp.	—	—

TABLE 4 — (Continuation)

Serial No.	Family	Genus	species	Maximum numbers per m² for Paired sample series	Sub sample series
M22	**Uropodina**	»	sp.	620	4,512
M23		»	sp.	1,240	940
M24		»	sp.	1,550	2,820
M25		»	sp.	—	5,452
M6 S	**Veigaiaidae**	*Veigaia*	*serrata* Berlese 1892	620	2,444
M6 N		*Veigaia*	*nemorensis* Koch 1839	1,240	1,316
M 46		*Gorirossia*	*whartoni* Farrier 1957	620	1,504
M12	**Pachylaelaptidae**	*Pachylaelaps*	spec. nov.	1,550	564
M13		*Pachylaelaps*	spec. nov.	620	376
M35		*Pachylaelaps*	spec. nov.	620	1,128
M21	**Parasitidae**	nymphs	sp.	310	564
M9	**Trachytidae**	»	sp.	1,550	376
M28	**Phytoseiidae**	»	sp.	—	564

the species present in the soil as well as the numbers of individuals attained by the species themselves. The genus *Gamasellus* is represented by the highest number of different species, but it is *Rhodacarellus* sp. (M 17) which developed the highest population density, 19,140 individuals per m² having been recorded in the natural forests. With reference to the number of different species present in the soil, the family Aceosejidae ranks second in importance to the Rhodacaridae and the family Laelaptidae third. It is interesting to note that less than 10 % of the species listed are known in the northern hemisphere and have been described there, and approximately 80 % of the species are new to science. This latter fact makes a comparison with the work of other soil ecologists in other countries, at the species level, impossible. However, the families and genera are well known and useful for a comparative study.

A very striking difference between the mesostigmatid fauna of the Magoebaskloof forest soils and those that have been described, for example, by WILLIAMS (1941), PEARSE (1946), van der DRIFT (1951) and KÜHNELT (1961) for American and European countries, is the unimportance of the Parasitidae in the Magoebaskloof soils as against the position in the above-mentioned

countries where the Parasitidae are abundant in species and individual numbers. In the Magoebaskloof forest soils the

Rhodacaridae
Aceosejidae
Laelaptidae
Macrochelidae
Uropodina
Veigaiaidae
Pachylaelaptidae,

in descending order of importance, all rank above the Parasitidae in abundance of both species and individuals. The same applies to the genus *Zercon;* species of this genus are common in American and European soils, but not a single species has been found in the Magoebaskloof soils.

On the other hand, many of the genera occurring in the Magoebaskloof forest soils have also been found in English, American and European forest soils. From the investigations of, for example WILLIAMS (1941), PEARSE (1946), BIRSFELDEN (1949), van der DRIFT (1951), FORSLUND (1944), FARRIER (1957), SELLNICK (1958), EVANS *et al.* (1961) and KÜHNELT (1961), it is clear that all the genera mentioned in table 4 also occur in these forests. Only the following few species, which are known to have a world wide distribution, have also been found in the Magoebaskloof forest soils:

Veigaiaidae: *Veigaia serrata*
Veigaia nemorensis
Gorirossia whartoni

The taxonomic structuring of the Mesostigmata in three South African pasture soils is well known as a result of the work that has been done on kikuyu *(Pennisetum clandestinum)* and *Eragrostis* pasture soil by RYKE (1965), on kikuyu pasture soil by OLIVIER & RYKE (1967) and on a *Themeda-Elyonurus* association pasture soil by LOOTS & RYKE (1966). The South African forest soils are taxonomically more closely related to the South African pasture soils than to the European forest soils, because these authors also found a notable absence of the families Parasitidae and Zerconidae in the Pasture soils they investigated. Furthermore, the forest soils and the pasture soils all had the Rhodacaridae as one of the dominant families. Although they have these features in common. the South African forest and

pasture soils also differ taxonomically in some important aspects, for example: (a) the family Veigaiaidae which is well represented in the Magoebaskloof forest soils is absent from the Potchefstroom pasture soils; (b) the Uropodina, which is numerically a very important group in the forest soils, is almost absent in the pasture soils; (c) on the other hand the Phytoseiidae, which are very abundant in the pasture soils occur in very low frequencies in the forest soils, and the Ameroseiidae are altogether absent from the forest soils; (d) many genera found in forest soil such as, for example, *Sejus, Proctolaelaps,* and *Iphidozercon* are absent from the pasture soils; (e) only a few Mesostigmata species were collected in both the forest and pasture soils namely *Asca aethiopica, Rhodacarus sublapideus* and *Leptolaelaps elegans;* the latter two were only found in one of the pasture soils, *L. elegans* in kikuyu pasture soil and *R. sublapideus* in the *Themeda-Elyonurus* pasture soil.

4.4. POPULATION DENSITY

4.4.1. *Sarcoptiformes*

In the Magoebaskloof forest soils the Sarcoptiformes not only occurred in great abundance but they also dominated the other Acari groups with reference to numbers. Of all the Acari that were collected in the Magoebaskloof forest soil the Sarcoptiformes contributed 65 % in numbers. Figure 7 shows, for example, the numerical dominance of the Sarcoptiformes at station D. In his survery of the cryptic fauna of forests, LAWRENCE (1953) found that the Arachnida comprised 46 % of the arthropod fauna in the evergreen forest soil at Champagne Castle, the Cryptostigmata (Oribatei) contributing 28 % to this fraction.

A comparison of the population densities of the Sarcoptiformes in the Magoebaskloof forest soil with those of forests in other countries shows that the numbers approach those that were, for example, recorded in the English forest by EVANS *et al.* (1961); an average of 139,120 per m^2 for 12 months was recorded in Magoebaskloof as against 60,00-284,000 per m^2 in some English forests.

The population densities are, however, much higher than those which were recorded by RYKE (1965), OLIVIER & RYKE (1967) and LOOTS & RYKE (1966) in the pasture soils near Potchefstroom. At peak population densities the numbers were approximately 23,000 per m^2 in the kikuyu pasture soil and 21,000 per m^2 in *Themeda-Elyonurus* pasture soil.

In English oak forests the Sarcoptiformes were found to constitute approximately 70 % of the acarofauna; in the Magoebaskloof forest soils the comparable figure was 65 % but in the South African pasture soils LOOT & RYKE (1966) found the comparable figures dropped to 25 % in the *Themeda-Elyonurus* pasture soil and 31 % in kikuyu pasture soil. These authors pointed out

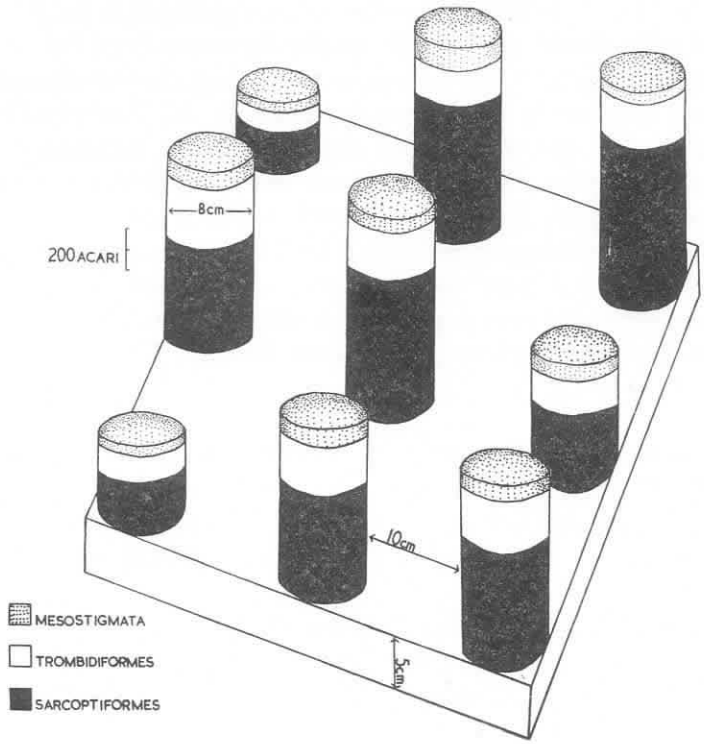

Fig. 7 — Distribution mites station D 4/1/62, in evergreen forest soil, 0-5 cm level

that there is a tendency for the Oribatei to be numerically less important in soils with a low organic content, low moisture content and high temperatures than in soils with high organic content, high moisture content and low temperatures. LOOTS & RYKE (1967) correlated the ratio $\frac{\text{Sarcoptiformes numbers}}{\text{Trombidiformes numbers}}$ with the amount of organic material in a number of soils for which the information is available in South Africa, and found that in soils with a high organic content the Sarcoptiformes were relatively numerous and the Trombidiformes less so whereas in soils with a low organic content the Trombidiformes

appeared to be the dominant group and the Sarcoptiformes to be few in numbers. The figures of the Magoebaskloof forest and pine plantation soils confirm their postulate; in the high organic content Magoebaskloof forest and pine plantation soils the Sarcoptiformes are numerically the dominant group but in the low organic content, *Eragrostis, Kikuyu* and *Themeda-Elyonurus* pasture soils the Trombidiformes are more abundant.

The authors wish to add to the observations of LOOTS & RYKE by pointing out that not only should the shift in quality be emphasized but also shift in quantity; not only do the Trombidiformes and Sarcoptiformes change positions but the overall numbers in mites have decreased. In the Potchefstroom pasture soils with their low organic material content and low moisture content, the trombidiform population densities did not increase at the expense of the Sarcoptiformes. Instead, both groups suffered under the extreme conditions but the Sarcoptiformes more so than the Trombidiformes (the population density levels of the forests are then used as a criterium) so that in the pasture soils a relatively poor population density of Trombidiformes developed but an even lower sarcoptiform population density. The following figures will illustrate the point.

	Magoebaskloof forest soil, favourable moisture content and organic material	Potchefstroom pasture soils, low moisture and organic material content
Sarcoptiformes	205,000 m^2	400-23,000 m^2
Trombidiformes	120,000 m^2	38,000 m^2

The observed low population densities of the Sarcoptiformes in the dry, low organic content soils in comparison with the forest soils, are in full accordance with what is already known of the feeding habits of the Sarcoptiformes.

In South Africa it has been found that a definite relationship exists between the water content, organic material content and range of temperature changes of a soil. Dry and warm pasture soils in South Africa usually have a very low organic content, approximately 10 % and less, whereas the moist forest soils have an organic content of over 50 % in the 0-5 cm layer. Associated with the organic material of the soil are populations of micro-plants which serve as food for many Sarcoptiformes. It is to be expected, therefore, that a soil with a high organic material content, other factors being favourable, will carry a big population of Sarcoptiformes and vice versa. Provided the conditions are favourable for the soil algae, fungi and bacteria, their numbers and total activity will increase as the supply of organic matter increases (RUSSEL 1957), and in consequence the number of Sarcoptiformes feeding

on the organic material itself and the microflora can attain higher population densities. According to RUSSEL (1957) there is, however, an upper limit for the microflora, set by biotic and abiotic factors, beyond which its numbers cannot increase. If the addition of organic material is still increased beyond this stage the organic matter then accumulate only in a partially decomposed condition; an increase in soil acidity and an exclusion of oxygen from the decomposition site, for instance, can cause such a state of affairs. With an increase in the organic content of a soil we can, therefore, expect an increase in the soil bacteria, algae and fungi and an accompanying increase in the organisms feeding on them, such as the Sarcoptiformes. But if unfavourable conditions develop in the soil, such as a drop in the oxygen availability or an abnormal increase in pH, the soil microflora will decrease in numbers and we must expect a decline in the numbers of the Sarcoptiformes.

4.4.2. *Trombidiformes*

The Magoebaskloof forest soil is rich in numbers and species of Trombidiformes, and although the population densities and species variation of the forest Sarcoptiformes are not matched, the counts that have been obtained are far in excess of the numbers collected in pasture soils in South Africa by RYKE (1965), OLIVIER & RYKE (1966) (table 5). At their respective times

TABLE 5 — **Average mite population densities in 0-5 cm layer of South African soils at times of peak population densities**

	nums/m²				
	Magoebaskloof forest soils		Potchefstroom pasture soils		
Mite group	Natural forests	Pine plantations	*Eragrostis*	Kikuyu	*Themeda-Elyonurus*
	July	Jul. Aug.	April	Jan.	Dec.
	1963	1963	1963	1963	1962
Mesostigmata	16,732	12,972	1,320	3,240	2,820
	July	Jul. Aug.	Jul.	Jul.	May
	1963	1963	1963	1963	1963
Trombidiformes	119,380	122,764	32,000	38,000	38,400
	July	July	Jul.	Aug.	Feb.
	1963	1963	1963	1963	1963
Sarcoptiformes	204,920	171,644	400	23,200	21,400

Potchefstroom pasture soil information from LOOTS & RYKE (1966).
OLIVIER & RYKE (1967).
RYKE (1965).

of peak population the Trombidiformes reached approximaly 38,000 per m^2 in kikuyu soil and 38,400 m^2 in *Themeda-Elyonurus* pasture soil, but 120,000 per m^2 in the Magoebaskloof evergreen forest soil. The natural forest and pine plantation soils in Magoebaskloof harboured aproximately the same

TABLE 6 — **Numbers of Tydeidae in 250 cc of soil from Magoebaskloof evergreen forest soils. (sample d = 8 cm, height 5 cm) (To obtain nums/m^2 for individual samples, multiply by 188)**

Station	Level	1962 Aug.	Sept.	Oct.	Nov.	Dec.	1963 Jan.	Feb.	Mar.	Apr.	May	Jun.	July
A	0–5 cm	73	56	704	183	50	52	68	106	173	199	369	136
	5–10 cm	22	33	27	51	26	1	8	4	37	12	33	24
	10–15 cm	6	11	36	24	59	2	1	8	11	14	6	5
B	0–5 cm	379	571	336	207	168	203	239	111	112	283	574	1,076
	5–10 cm	212	124	4	55	52	24	89	91	21	52	78	101
	10–15 cm	125	28	4	8	6	4	15	17	3	1	56	54
C	0–5 cm	172	79	136	88	73	53	68	73	135	66	988	393
	5–10 cm	92	198	0	1	25	6	7	27	49	39	26	36
	10–15 cm	29	10	3	3	1	4	0	9	19	12	8	18
D	0–5 cm	324	152	262	112	49	58	27	14	19	232	102	99
	5–10 cm	41	25	12	11	4	6	29	11	9	16	54	96
	10–15 cm	16	12	14	3	2	6	18	9	2	15	13	19
E	0–5 cm	188	285	204	54	32	61	72	49	43	62	88	143
	5–10 cm	31	32	8	3	13	15	9	12	18	59	80	52
	10–15 cm	6	28	9	4	7	3	7	2	12	37	27	24
F	0–5 cm	1,544	108	62	168	176	203	28	117	162	72	103	106
	5–10 cm	49	58	24	18	16	12	63	12	26	39	34	52
	10–15 cm	8	9	7	8	4	23	22	0	2	25	21	52
	Total	3,317		1,852		763		770		853		2,660	
			1,819		1,001		736		672		1,235		2,483

Average 1,513

population densities of Trombidiformes viz. 119,380 per m^2 in the natural forest as against 122,764 m^2 in the pine plantations.

Tables 6 to 9 show the population densities of the families Tydeidae, Eupodidae, Scutacaridae and the rest of the trombidiform families as a group. For the family Tydeidae much higher population densities were recorded in

the forest soils than in the pasture soils. The seasonal variations in population density of this family in the Magoebaskloof forest soils show the same pattern as the pasture soils around Potchefstroom; both soils have a winter maximum and an early summer minimum.

TABLE 7 — **Numbers of Eupodidae in 250 cc of soil from Magoebaskloof evergreen forest soils. (sample d = 8 cm, height 5 cm)**
(To obtain nums/m² for individual samples, multiply by 188)

Station	Level	1962 Aug.	Sept.	Oct.	Nov.	Dec.	1963 Jan.	Feb.	Mar.	Apr.	May	Jun.	July
A	0–5 cm	22	14	95	36	4	8	15	28	24	25	129	41
	5–10 cm	3	7	3	16	0	2	3	5	1	4	24	2
	10–15 cm	9	3	5	7	4	1	0	3	0	6	10	0
B	0–5 cm	39	46	16	3	21	14	29	22	39	14	65	161
	5–10 cm	87	5	3	2	8	5	18	49	25	17	19	17
	10–15 cm	20	8	0	3	4	0	6	8	2	1	6	5
C	0–5 cm	71	39	46	49	16	9	15	13	17	14	152	226
	5–10 cm	49	64	1	0	5	0	2	9	20	10	4	19
	10–15 cm	8	7	1	4	0	2	0	3	7	8	0	9
D	0–5 cm	152	52	34	7	6	7	6	7	10	28	33	30
	5–10 cm	7	4	8	3	8	5	10	9	1	8	6	16
	10–15 cm	0	27	4	0	1	2	9	10	4	9	9	4
E	0–5 cm	65	48	64	9	18	12	13	12	17	32	36	73
	5–10 cm	18	14	0	2	1	2	3	7	6	17	4	29
	10–15 cm	0	0	1	6	1	1	0	3	2	6	4	2
F	0–5 cm	98	55	10	36	112	42	3	21	140	16	31	59
	5–10 cm	17	9	8	0	2	4	2	3	6	17	11	9
	10–15 cm	0	0	2	0	5	0	3	0	2	8	9	3
	Total	664	402	301	183	216	116	137	212	323	240	552	714

Average 340

The average population density of the Trombidiformes in the 0-5 cm layer of the Magoebaskloof forest soils for 12 months is approximately 65,800 per m², a figure which compares favourably with 87,000 per m² for an English oak forest (soil depth unknown) quoted by EVANS *et al.* (1961).

TABLE 8 — **Numbers of Scutacaridae in 250 cc of soil from Magoebaskloof evergreen forest soils. (sample d = 8 cm, height 5 cm) (To obtain nums/m² for individual samples, multiply by 188)**

Station	Level	1962 Aug.	Sept.	Oct.	Nov.	Dec.	1963 Jan.	Feb.	Mar.	Apr.	May	Jun.	July
A	0–5 cm	35	16	16	21	15	69	63	29	27	51	25	42
	5–10 cm	1	9	15	5	31	10	23	20	15	5	27	4
	10–15 cm	13	5	9	4	2	11	18	10	4	9	6	31
B	0–5 cm	124	18	75	42	135	62	109	32	20	91	48	24
	5–10 cm	64	2	56	55	23	38	62	51	59	37	29	3
	10–15 cm	24	4	10	28	14	11	32	16	37	21	4	21
C	0–5 cm	28	29	28	17	41	27	66	67	178	71	29	119
	5–10 cm	32	17	8	0	6	2	7	49	81	13	26	21
	10–15 cm	8	0	4	13	3	8	1	2	13	10	0	6
D	0–5 cm	64	22	11	43	32	17	34	21	25	104	37	231
	5–10 cm	10	16	5	32	4	28	13	13	29	21	8	97
	10–15 cm	8	21	18	3	3	33	18	14	15	6	14	2
E	0–5 cm	109	56	88	27	152	60	52	82	153	68	119	267
	5–10 cm	43	4	17	10	14	40	18	26	8	18	32	38
	10–15 cm	0	4	18	18	15	28	7	29	4	57	6	11
F	0–5 cm	75	136	44	29	48	23	35	58	29	161	73	69
	5–10 cm	10	1	8	2	5	58	21	23	7	51	15	48
	10–15 cm	1	5	7	2	1	20	9	0	11	17	4	23
	Total	645	365	437	351	544	545	588	542	715	811	502	105

Average 512

4.4.3. *Mesostigmata*

Figure 8 compares the average population density of the Mesostigmata in the Magoebaskloof evergreen forest soils with that of the Sarcoptiformes and Trombidiformes. The Mesostigmata constituted a relatively small proportion of the forest soil Acarofauna (5.5 %) with an average population density of 12,728 per m² in the 0-5 cm layer. It is to be expected, however, that the Mesostigmata will be fewer in numbers than the Sarcoptiformes and probably also than the Trombidiformes, because although we know very little about the feeding habits of the Trombidiformes, we do know that the

majority of the Sarcoptiformes feed on plant material and the majority of the Mesostigmata are predators and, therefore, in order to maintain the normal trophic level stability, the community must be considerably fewer than the herbivores.

TABLE 9 — **Numbers of Trombidiformes (other than Tydeidae, Eupodidae and Scutacaridae) in 25 cc of soil from Magoebaskloof evergreen forest soils. (sample d = 8 cm, height 5 cm) (To obtain nums/m² for individual samples, multiply by 188)**

Station	Level	1962 Aug.	Sept.	Oct.	Nov.	Dec.	1963 Jan.	Feb.	Mar.	Apr.	May	Jun.	July
A	0–5 cm	23	52	132	17	24	33	13	27	34	35	128	68
	5–10 cm	4	12	13	24	5	4	7	4	10	7	8	31
	10–15 cm	5	3	6	17	13	5	8	3	7	22	12	8
B	0–5 cm	15	69	11	16	34	22	26	47	48	47	208	164
	5–10 cm	52	48	9	35	45	36	4	48	92	56	18	16
	10–15 cm	36	16	4	44	7	24	2	11	23	10	16	8
C	0–5 cm	52	29	35	18	10	11	8	24	56	26	144	78
	5–10 cm	18	78	5	0	4	4	5	13	6	17	22	24
	10–15 cm	7	22	3	5	1	4	0	1	2	2	3	14
D	0–5 cm	84	14	15	5	12	30	9	13	225	62	25	71
	5–10 cm	2	16	12	6	10	7	13	28	72	264	18	82
	10–15 cm	4	32	9	2	1	8	8	7	6	14	13	9
E	0–5 cm	102	144	208	13	14	17	25	47	25	24	17	111
	5–10 cm	5	8	12	9	24	17	12	19	8	52	36	84
	10–15 cm	4	20	21	10	9	6	9	4	32	32	12	6
F	0–5 cm	54	11	12	32	42	22	21	21	82	67	24	14
	5–10 cm	10	0	3	0	8	20	18	16	4	16	13	40
	10–15 cm	5	0	8	6	3	27	7	1	0	11	5	12
	Total	482	574	522	259	266	297	195	404	732	764	722	840

Average 505

Table 4 shows the maximum population densities that were recorded for the different species of Mesostigmata. A comparison of the average population densities of the various mesostigmatid families with each other shows the order of numerical importance to be Rhodacaridae first, with 9,400 mites per m², and the Aceosejidae and Uropodina jointly second with 1,128 mites

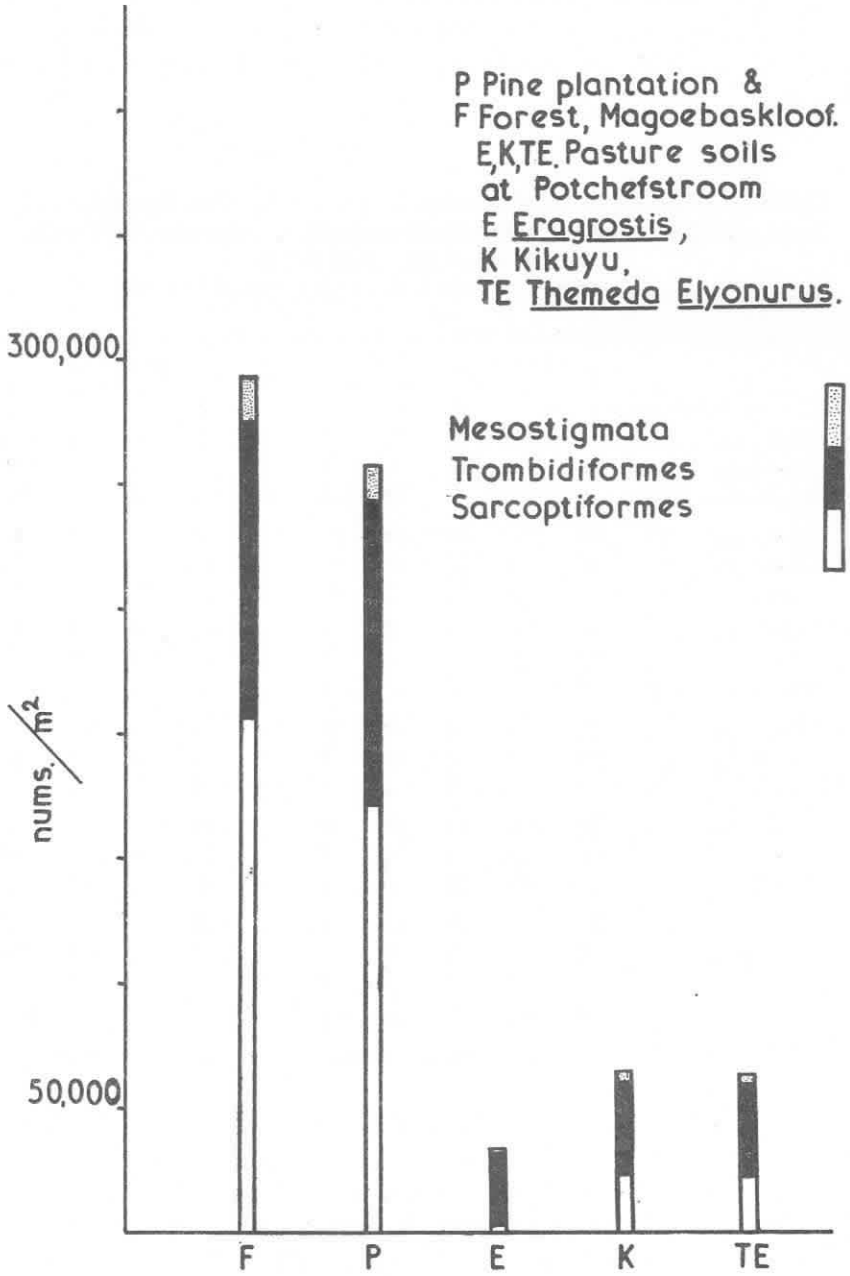

Fig. 8 — Average Acari-population densities in 0-5 cm layer of South African soils

per m². The big difference in population density between the Rhoracaridae and the second group is conspicuous. The Laelaptidae is third, the Veigaiaidae fourth and the Pachylaelaptidae fifth. The families Macrochelidae, Parasitidae, Trachytidae and Phytoseiidae were found in very low numbers.

In the various types of soils which have been studied in South Africa the families of the Mesostigmata compare as follows in order of abundance:

	Magoebaskloof forest soil	Potchefstroom pasture soils	
		Kikuyu soil	*Themeda-Elyonurus* soil
1.	Rhodacaridae	Rhodacaridae	Rhodacaridae
2.	Uropodina	Laelaptidae	Aceosejidae
3.	Aceosejidae	Phytoseiidae	Phytoseiidae
4.	Laelaptidae	Aceosejidae	Laelaptidae
5.	Veigaiaidai	Macrochelidae	Pachylaelaptidae
6.	Pachylaelaptidae	Uropodina	Ameroseiidae
7.	Macrochelidae		Uropodina
8.	Parasitidae		
9.	Trachytidae		
10.	Phytoseiidae		

In the *Themeda-Elyonurus* pasture soil LOOTS & RYKE (1966) found the Rhodacaridae and Aceosejidae to have comparable population densities. In pasture soils the Rhodacaridae play a dominant role but in the forest soil the population density is about eight times that of the other soils. The Aceosejidae have a comparable population density in the forest soil and *Themeda-Elyonurus* pasture soil.

Table 4 shows that many of the Rhodacaridae species realised exceedingly high population densities in the Magoebaskloof forest soils viz. *Rhodacarellus* sp. (M 17), *Gamasellus* sp. (M 16) and *Rhodacarus rhodacaropsis*, but it is interesting to note that it tends to be the group of species which is not only surface layer inhabitants but which also inhabits the deeper soil layers (5-15 cm).

Although the numbers of the Mesostigmata that were recorded in the Magoebaskloof forest soils are very high compared with those in the South African pasture soils (fig. 8) the densities compare very favourably with the figures of EVANS *et al.* (1961) for English forest soils and di CASTRI (1963) for South American forest soils. Unfortunately the population density figures of a number of authors could not be used for a comparative study because the sample sizes and or sample depths were not specified, but in general the population densities of the Mesostigmata in the Magoebaskloof natural forest

soil appear to be of the same magnitude as in the forests of Europe and the Scandinavian Isles.

Fig. 8 show that the population density of the Mesostigmata *in toto* in the natural forest is slightly higher than in the pine plantations. The population density of many species have changed, for example, *Rhodacarellus* sp. (M 17), which had a very high population density in the natural forest, recorded very low densities in the pine plantations, whereas the reverse is true for *Gaeolaelaps* sp. (M 42).

4.5. HORIZONTAL SPATIAL DISTRIBUTION

The horizontal spatial distribution of the soil Acari has only since recently been investigated and mainly with the aid of two techniques, or a combination of the two. Using a mapping technique, MURPHY (1955) for example, showed that the Acari as a group are distributed in agregated patches: fig. 7 show that this is also true for the acarine groups in the Magoebaskloof forest soils. HARTENSTEIN (1961) and NEF (1962), using a graphical statistical method, showed that this was also true for individual species of the Cryptostigmata, and GIFFORD (1964) with the same technique showed the same for species of the genus *Veigaia*. If a population of soil organisms consists of randomly located individuals, the distribution can be described mathematically with the aid of a «Poisson form». Soil organisms are, however, rarely randomly distributed; probably for feeding, reproducing and other reasons the organisms aggregate and the resultant mathematical description of such an aggregation is a contagious distribution curve for which several mathematical models have been worked out. HARTENSTEIN (1961) and NEF (1962) have shown that the «Negative Binomial» distribution curve describes the distribution of aggregated acarine populations effectively.

4.6. COLONY SIZE AND NUMBER

HUGHES (1962) developed a mathematical technique for estimating the size and number of aggregates in a soil community. The technique entails, briefly, the following: samples are taken in pairs spread over the area of the habitat that is to be studied, the position of one of each pair is fixed by an unbiased method, while the other is taken at a fixed distance from the first in a random direction. For a particular animal species counted numbers from the paired samples are used to estimate the ratio of the area of the species aggregate to the length of its perimeter, by applying the formulas 3 and 4 men-

TABLE 10 — **Mite numbers in 20 paired samples taken at station A, 20/7/64, from a slab of soil 3 × 1.5 meters and 5 cm deep, sample diameter 6.4 cm, height 5 cm**

Mite species	Sample pairs																			
	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B
Rhodacarellus sp. (M17)	18	31	0	13	3	17	4	1	8	8	22	21	15	8	2	0	1	9	5	11
Gamasellus natalensis (M2)	2	3	0	2	2	4	4	9	9	6	1	2	2	1	0	0	6	0	8	1
Gamasellus sp. (M7)	8	2	2	14	0	22	4	2	8	5	2	11	12	4	2	1	6	2	7	2
Leptolaelaps elegans (M26)	2	3	0	0	2	5	1	0	1	0	6	1	0	1	0	0	0	0	0	2
Total Mesostigmata	37	53	15	52	22	86	24	40	36	38	43	48	57	19	17	31	36	17	39	35
» Sarcoptiformes	139	115	25	281	55	347	124	527	160	97	433	275	156	53	131	151	111	18	221	143
» Trombidiformes	77	174	50	300	73	278	122	382	88	65	234	287	111	77	135	40	85	11	116	123

	Sample pairs																			
	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	16B	17A	17B	18A	18B	19A	19B	20A	20B
Rhodacarellus sp. (M17)	5	3	12	37	30	2	15	2	12	11	11	1	3	3	5	0	2	3	11	19
Gamasellus natalensis (M2)	0	1	5	1	0	1	0	2	3	1	1	0	2	3	0	1	3	0	0	4
Gamasellus sp. (M7)	0	1	12	13	0	17	7	3	10	11	22	1	2	4	6	2	13	0	6	0
Leptolaelaps elegans (M26)	2	2	2	1	2	0	2	5	0	0	1	1	2	0	1	0	4	0	1	2
Total Mesostigmata	11	12	37	78	44	30	42	27	34	38	104	38	27	33	22	24	46	7	41	41
» Sarcoptiformes	56	122	156	450	222	164	316	144	249	313	391	65	161	151	164	150	191	37	237	165
» Trombidiformes	46	249	121	291	169	129	405	63	427	154	244	44	86	146	151	57	119	61	187	19

tioned below. This ratio defines the amount of break up of areas of high population density and, if certain assumptions can be made, provides an estimate of the mean radius of the aggregates of the species, and thus their number. The reader is referred to HUGHES (1962) for more theoretical detail and references. This technique was also used to estimate, where possible, the size and number of the aggregates of species of the Mesostigmata in the Magoebaskloof evergreen forest soils.

The sampling area was selected at Station A, a rectangular space 3 meters by 1.5 meters; this is area A in the undermentioned formulas. Twenty pairs of samples (total forty samples) were taken with the tie lines (q) equal to 10 cm; the size of the samples was 6.4 cm diameter with a height of 5 cm. The numbers of Mesostigmata that were extracted from the paired samples are shown in table 10 and the size groups (aggregate sizes) that were selected and the calculated results are shown in tables 11 A to D.

Pa for selected aggregate (or size group) is the probability that random samples in the area investigated (area A) will fall in the aggregate selected.

If r is the radius of the particular aggregate then

$$Pa = \frac{II\, r^2}{A} \qquad (1)$$

But Pa for a certain arbitrarily selected colony size is also equal to

$$\frac{\text{the number of higher density samples}}{\text{total number of samples}} \text{ (h.d.s.)}$$

TABLE 11a. — *Rhodacarellus* **spec. nov. (M17) number of aggregates** (n) **in 3 m by 1.5 m soil, 5 cm deep, at station A, and the calculated mean radius** (r) **of these aggregates**

Group size	s.f.	h.d.s.	Pa	q crosses	Pc	r	n
0–4	13	24	0.6	8	0.	19.1 cm	23
5–9	7	17	0.42	7	0.35	15.2 cm	25
10–14	7	10	0.25	6	0.3	10 cm	31
15–19	5	5	0.12	3	0.12	10 cm	22
20–24	2	3	0.075	3	0.15	6.3 cm	—
25–29	0	3	0.075	3	0.15	6.3 cm	—
30–34	2	1	0.025	1	0.05	—	—
35 +	1	—	—	—	—	—	—

(s.f. = sample frequency)
(h.d.s. = number of higher density samples)

TABLE 11b. — *Gamasellus natalensis* (M2) number of aggregates (n) in 3 m by 1.5 m soil, 5 cm deep at station A and the calculated mean radius (r) of of these aggregates

Group size	s.f.	h.d.s.	Pa	q crosses	Pc	r	n
0–4	23	6	0.15	4	0.2	9.5 cm	23
5–9	6	—	—	—	—	—	—

(s.f. = sample frequency)
(h.d.s. = number of higher density samples)

TABLE 11c. — *Gamasellus* spec. nov. (M7) number of aggregates (n) in 3 m by 1.5 m soil, 5 cm deep at station A and the calculated mean radius (r) of these aggregates

Group size	s.f.	h.d.s.	Pa	q crosses	Pc	r	n
0–4	16	19	0.475	13	0.65	9.3 cm	78
5–9	8	11	0.275	7	0.35	10 cm	39
10–14	8	3	0.075	3	0.15	6.3 cm	—
15–19	1	2	0.05	2	0.10	6.3 cm	—
20–24	1	1	0.025	1	0.05	—	—
24 +	—	—	—	—	—	—	—

(s.f. = sample frequency)
(h.d.s. = number of higher density samples)

TABLE 11d. — *Leptolaelaps elegans* (M26) number of aggregates (n) in 3 m by 1.5 m soil, 5 cm deep, at station A and the calculated mean radius (r) of these aggregates

Group size	s.f.	h.d.s.	Pa	q crosses	Pc	r	n
0–4	21	3	0.075	3	0.5	19.05 cm	26
5–9	3	—	—	—	—	—	—

(s.f. = sample frequency)
(h.d.s. = number of higher density samples)

Pc for a selected aggregate (or size group) is the probability that the tie line crosses the edge of the selected aggregate. If q is the tie line then

$$Pc = \frac{4rq}{A} \qquad (2)$$

But Pc for a certain arbitrarily selected colony size is also equal to

$$\frac{\text{the number of tie line crosses}}{\text{the number of pairs of samples}}$$

For an area containing many distinct aggregates (n), the equations for Pa and Pc now become

$$Pa = \frac{n \Pi r^2}{A}$$

$Pc = \frac{4rqn}{A}$ and from these an expression for the mean radius can be derived

$$r = \frac{4qPa}{\Pi Pc} \qquad (3)$$

Using this expression for mean radius the number of aggregates is given by

$$n = \frac{Pc^2A\Pi}{16q^2Pa} \qquad (4)$$

Note, however, that when the colony radius is less than q/2, Pc = 2Pa independently of q, and substitution of 2Pa for Pc in the expression for r shows the estimate of r to depend solely on q and to be quite independent of other factors

$$r = \frac{2q}{\Pi} = 0.637q$$

Using q as 10 cm, r then remains a constant 6.37 for all those aggregate radii which are less than q/2.

Using the results of table 10 and applying formulas 3 and 4, an attempt was made to work out the number of aggregates of the following species in an area (3 m × 1.5 m) at station A, and to calculate the mean radius for every aggregate:

Rhodacarellus spec. nov. (M 17)
Gamasellus spec. nov. (M 7)
Leptolaelaps elegans (M 26)
and *Gamasellus natalensis* (M 2)

The results that were obtained for *Rhodacarellus* sp. (M 17) are shown in table 11A, and these results were calculated as follows:

Using the results of table 10 for *Rhodacarellus* sp. (M 17) the tie line crosses for the 0-4 group of table 11A are obtained as follows: every pair of results in which the figure in the A column is less than five (i. e. four and smaller) and the figure in the B column is bigger than four (. e. five or more), is calculated as one tie line crossing; Using the same pair of columns but from another direction — if the figure in the B column is less than five and the figure in the A column is five or more, it is calculated as a second tie line crossing.

Thus for the particular size group in question there are 8 tie line crosses.

$$Pa = \frac{\text{the number of higher density samples}}{\text{total number of samples}} \text{ (h.d.s.)}$$

$$= \frac{24}{40} \text{ for the 0-4 group}$$

$$= 0.6$$

$$Pc = \frac{\text{the number of tie line crosses}}{\text{the number of pairs of samples}}$$

$$= \frac{8}{20} \text{ for the 0-4 group}$$

$$= 0.4$$

The mean radius of the 0-4 groups is then given by:

$$r = \frac{4\,qPa}{II\,Pc}$$

$$= \frac{4 \times 10 \times 0.6}{3.14 \times 0.4}$$

$$= 19.1 \text{ cm}$$

The number of 0-4 groups in the 3 meters $\times$ 1½ m samples area is then given by:

$$n = \frac{Pc^2\,AII}{16\,q^2\,Pa}$$

$$= \frac{0\ 4 \times 0.4 \times 45.000 \times 3.14}{16 \times 10 \times 10 \times 0.6}$$

$$= 23.5 \text{ groups}$$

For the other population density groups n and r are worked out in the same way and for the other Mesostigmata the results of tables 11 A to D have been worked out in the same way.

From table 11 A the following deductions can be made:

Rhodacarellus sp. (M 17) have in a soil slab 3 m by 1.5 m and 5 cm deep, at Station A, the following colony sizes in order of abundance:

1st	colonies	with	10	to	14	individuals	with	a	diam.	of	10 cm
2nd	»	»	5	»	9	»	»	»	»	»	15.2 cm
3rd	»	»	1	»	4	»	»	»	»	»	19.1 cm
4th	»	»	15	»	19	»	»	»	»	»	10 cm

Unfortunately because of their low population densities, the results that have been obtained for the other three species do not make a comparison possible. As soon as r becomes a constant it indicates that the colony radii are smaller than q/2, that is, smaller than 5 cm.

4.7. VERTICAL DISTRIBUTION

Table 12 shows the frequency with which the different Mesostigmata occurred in the various soil layers as a percentage of the total number of samples for that particular layer. It is evident from the table that the species show preferences for certain layers. Mites such as *Gamaselliphis* sp. (M 1) and *Asca aethiopica* definitely prefer the surface layer, whereas *Rhodacarellus* sp. (M 17), *Gamasellus* sp. (M 43), *Gamasellus* sp. (M 52) and *Notogamasellus* sp. (M 48) prefer the deeper layers where the mineral content of the soil is about 40 % or more. However, the largest numbers were found in the surface layers and the numbers were found to become less and less with increasing depth of the soil. Table 13 shows the few mites that were encountered at a depth of 1 m at station A. This pattern of distribution is already well known and has already been reported by many investigators for grass and forest soils, for example TRÄGARDH (1928), EVANS (1950), WEIS-FOGH (1948), van der DRIFT (1951), MURPHY (1953), BELFIELD (1956), SHEALS (1957) and HAARLOV (1955, 1960). EVANS *et al.* (1961) found that a considerable number of the British soil Mesostigmata were markedly hemiedaphic in character, preferring the upper 2-3 cm of the litter layer. Some species, such as those belonging to the genera *Digamasellus* and *Arctoseius*, were hemiedaphic forms but were also found to be able to penetrate the deeper

TABLE 12 — **Sample frequency of Mesostigmata in Magoebaskloof forest soils**

Serial No.	Genus and species	0–5 cm layer	5–10 cm layer	10–15 cm layer
M1	*Gamaseliiphis* spec. nov.	90	2	0
M32	*Gamaselliphis* spec. nov.	23	2	0
M38	*Gamaselliphis* spec. nov.	55	2	4
M2	*Gamasellus natalensis*	47	2	1
M3	*Gamasellus* spec. nov.	51	2	2
M4	*Gamasellus nkandhlaensis*	0	1	1
M7	*Gamasellus* spec. nov.	84	14	2
M16	*Gamasellus* spp.	83	45	19
M34	*Gamasellus* spec. nov.	37	19	2
M43	*Gamasellus* spec. nov.	14	39	25
M45	*Gamasellus* spec. nov.	38	40	22
M52	*Gamasellus* spec. nov.	8	14	18
M5	*Gamasiphis* spec. nov.	47	4	4
M15	*Gamasiphis* spec. nov.	58	21	4
M33	*Gamasiphis* spec. nov.	9	0	1
M17	*Rhodacarellus* spec. nov.	80	88	86
M18	*Rhodacarus rhodacaropsis*	93	95	89
M20	*Rhodacarus sublapideus*	7	0	0
M19	*Digamasellus* spec. nov.	2	1	0
M41	*Gamasellodes* spec. nov.	15	4	1
M47	*Gamasellodes* spec. nov.			
M48	*Notogamasellus* spec. nov.	4	9	10
M44	*Gamasellopsis* spec. nov.	4	7	7
M8	*Sejus* spec. nov.	12	0	0
M10	*Plesiosejus* spec. nov.	33	4	1
M11	*Proctolaelaps* spec. nov.	27	0	1
M14	*Lasiosejus* spec. nov.	5	0	1
M27	*Asca aethiopica*	60	1	0
M37	*Asca* spec. nov.	14	1	0
M39	*Iphidozercon* spec. nov.	19	0	0
M26	*Leptolaelaps elegans*	70	36	12
M29	*Cosmolaelaps* spec. nov.	7	7	1
M42	*Gaeolaelaps* spec. nov.	4	4	1
M40	*Hypoaspis speculifer*	8	2	2
M30	*Holotaspella* spec. nov.	2	1	0
M31	*Macrocheles* spec. nov.	10	1	0
M36	*Macrocheles* spec. nov.	1	0	0
M53	Macrochelidae nymphs	—	—	—
M22	Uropodina sp.	51	51	26
M23	Uropodina sp.	60	2	0

TABLE 12 — **(Continuation)**

Serial No.	Genus and species	0–5 cm layer	5–10 cm layer	10–15 cm layer
M25	Uropodina sp.	61	30	23
M6 S	*Veigaia serrata*	25	8	2
M6 N	*Veigaia nemorensis*	10	0	0
M46	*Gorirossia whartoni*	14	2	0
M12	*Pachylaelaps* spec. nov.	37	4	0
M13	*Pachylaelaps* spec. nov.	8	0	1
M35	*Pachylaelaps* spec. nov.	17	1	0
M21	Parasitidae nymphs.	5	1	0
M9	Trachytidae sp.	5	0	0
M28	Phytoseiidae sp.	4	0	1
M19	*Digamasellus* spec. nov.	2	1	0
M41	*Gamasellodes* spec. nov.	15	4	1
M47	*Gamasellodes* spec. nov.			
M48	*Notogamasellus* spec. nov.	4	9	10
M44	*Gamasellopsis* spec. nov.			
M8	*Sejus* spec. nov.	12	0	0

soil layers. Species of *Rhodacarellus* and *Rhodacarus* preferred the deep soil layers; the same was found for these two latter genera in the Magoebaskloof forest soils. HURLBUTT (1964) found euedaphic forms in Maryland soils in the families Rhodacaridae, Parholaspidae, Laelaptidae, Parasitidae and Veigaiidae. The Magoebaskloof forest soil euedaphic forms

Gamasellus sp. (M 43)
Gamasellus sp. (M 45)
Gamasellus sp. (M 52)
Rhodacarellus sp. (M 17)
Rhodacarus rhodacaropsis (M 18)
Notogamasellus sp. (M 48)
Gamasellopsis sp. (M 44)

all belong to the family Rhodacaridae. The family Rhodacaridae therefore, is represented by both hemiedaphic and euedaphic species but in contrast the families Aceosejidae and Macrochelidae have mainly surface layer inhabiting species.

TABLE 13 — **Number of Acari in 250 cc soil at a depth of 1 m at station A (sample d = 8 cm, 5 cm deep)**

Sample num.	Sarcoptiformes	Trombidiformes	Mesostigmata
1	2	2	1 *Rhodacarus rhodacaropsis*
2	3	1	2 *Rhodacarellus* sp. (M17)
3	—	2	—
4	2	1	1 *Rhodacarus rhodacaropsis*
5	1	—	—
6	1	1	2 *Rhodacarus rhodacaropsis*
			1 *Gamasellus* sp. (M16)
7	11	19	1 *Rhodacarus rhodacaropsis*
8	3	3	1 *Rhodacarus rhodacaropsis*
9	—	—	—
10	5	3	—
11	—	—	—
12	4	4	—
13	1	10	1 *Rhodacarellus* sp. (M17)
14	2	7	1 *Rhodacarus rhodacaropsis*
15	—	1	—
16	2	9	—
17	2	5	1 *Rhodacarus rhodacaropsis*
			1 *Notogamasellus* sp. (M48)
18	1	2	—

4.8. VERTICAL MIGRATION

With regard to vertical migrations, FRENZEL (1936) observed none in Silesian meadow soils; RIHA (1944), however, found migratory tendencies of Cryptostigmata in southern Vienna woods which were probably associated with water changes in the soils caused by melting snows. KARPPINEN (1955) found in Finnish soils that some Cryptostigmata migrate up and down in accordance with the seasons, while others do not. According to KÜHNELT (1961), experiments which demonstrate the sensitivity of oribatids towards rapid temperature changes, show that temperature is essentially responsible for vertical migrations.

In the Magoebaskloof forest soils no large scale annual mass migrations could be detected in any of the acarine groups. However, there are certain peculiarities in the annual and vertical distribution curves of the soil Acari which suggest that migrations may take place on a small scale. Fig 9 shows,

for example, the changes in population density of the Sarcoptiformes that took place in the upper layers at Station C in the Magoebaskloof evergreen forest soil during the period 11.8.1962 to 23.7.1963. In general, decreases in population density in the upper layers are followed by similar decreases in the

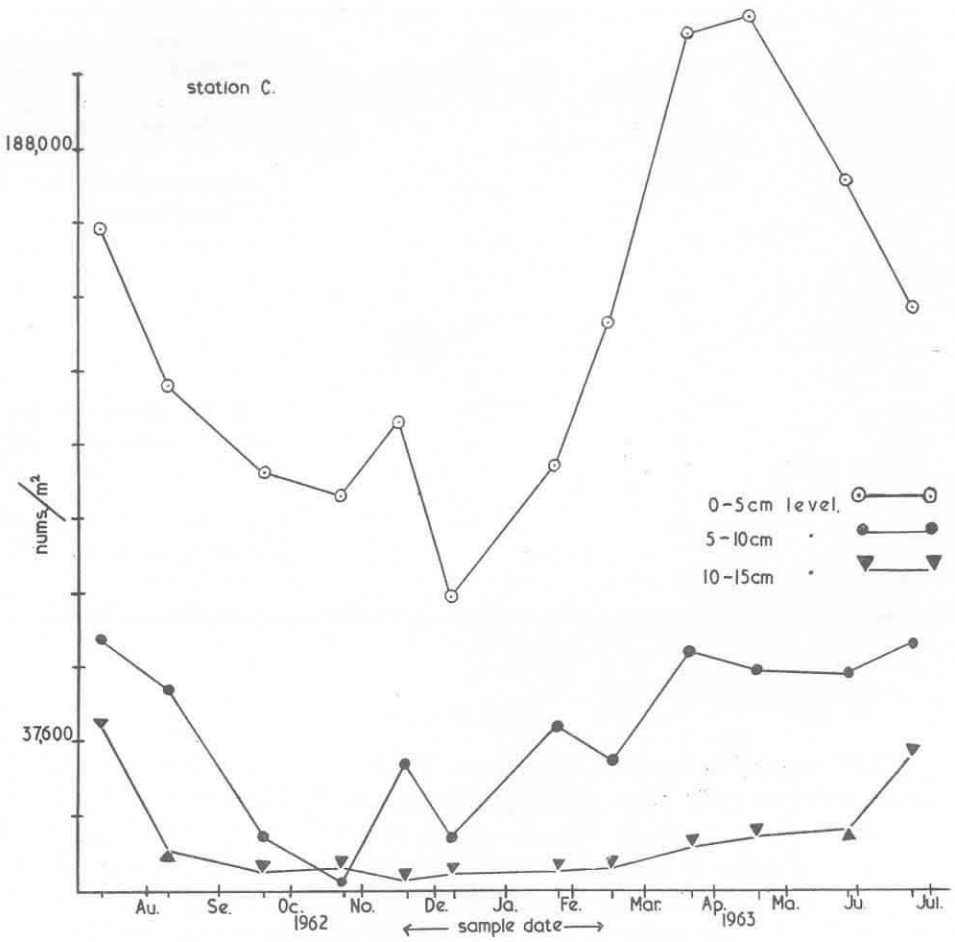

Fig. 9 — Sarcoptiformes seasonal variation population density Station C

lower layers and vice versa, indicating little or no migration. The population density increase in the 0-5 cm layer during the period March to April is approximately 75,200 individuals per m^2 but there were only 21,996 individuals per m^2 in the 5-10 cm layer and 4,076 individuals per m^2 in the next layer down, so that the big increase in the upper layer could not have been

mainly the result of migration from the lower layers. On the other hand, the density change during November 1962 in the 5-10 cm layer where it falls below that of the 10-15 cm layer, may indicate a migration on a small scale. It must, however, only be accepted as an indication and not as proof, because

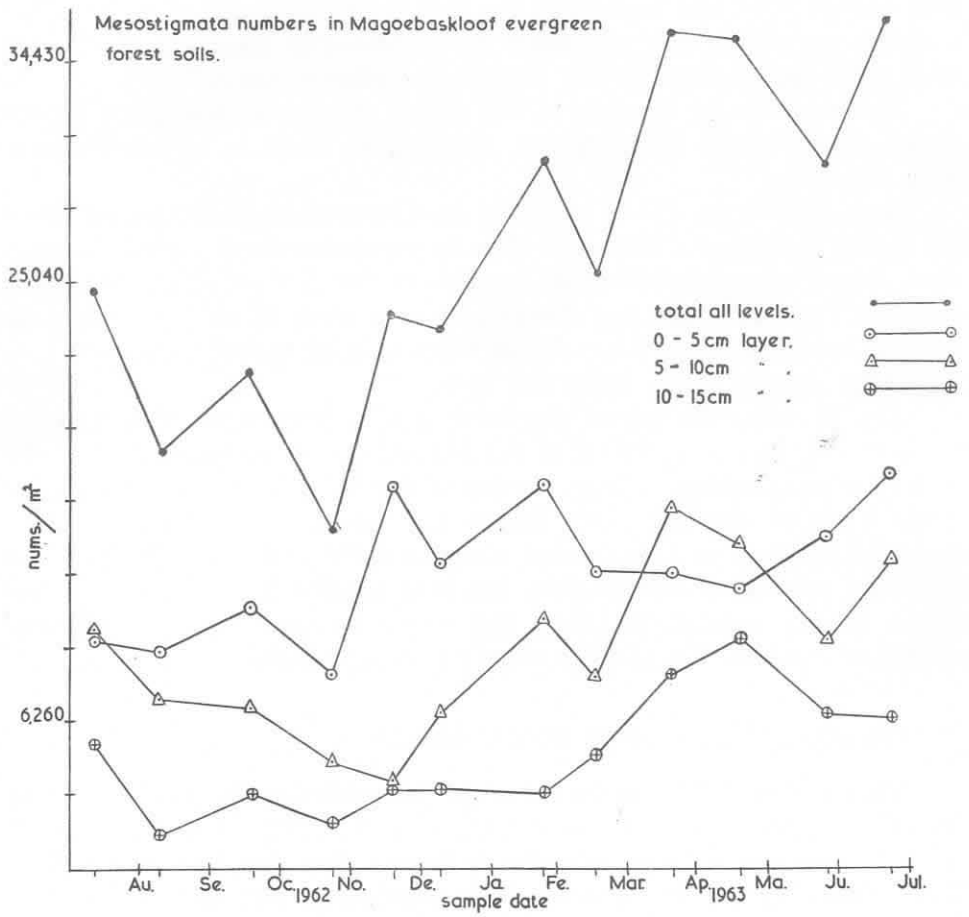

Fig. 10 — Mesostigmata numbers in Magoebaskloof evergreen forest soils

experimental errors in the extraction and counting of the organisms and their irregular distribution in the soil could have influenced the «density change» on the 23.11.1962 and a similar one at station A on the 19.3.1963.

Figure 10 shows the annual density changes of the Mesostigmata in the upper soil layers in the Magoebaskloof evergreen forest soil for the period

August 1962 tot July 1963. In general, changes in the upper layers are followed by similar changes in the lower layers but there are three instances where the graph lines cross and suggest possible migrations. For instance, during the period February 1963 to May 1963, the general tendency of the population density in the 0-5 cm layer was to decrease, whereas the tendency in the lower layer was to increase, so that eventually the 5-10 cm layer had a denser population than the upper layer. Migration from the upper layer could have caused these density changes or enhanced them.

An inspection of the data of the annual changes in population density of the species of the Mesostigmata, shows some instances of possible small scale migrations.

Gamaselliphis sp. (M 1) is mainly an inhabitant of the 0-5 cm soil layer, but during January and February when its population density was at a maximum, it was also found in small numbers in the 5-10 cm layer. These few individuals probably migrated downwards as a result of the competition for food or living space or other similar factors, which resulted from the high population density in the upper soil layer.

Fig. 14 shows the annual population density fluctuations of *Rhodacarus rhodacaropsis* in various layers of the Magoebaskloof evergreen forest soils. There are an exceptionally large number of density shifts between the various upper layers of the soil; these density changes are too pronounced to be explained in terms of experimental errors and differential distributions. The shifts are at present unintelligible, but it is possible that with more information on the reproduction habits, and temperature and humidity sensitivity of this mite species, the changes may become meaningful.

4.9. SEASONAL POPULATION DENSITY CHANGES

More or less at the time the techniques for extracting the Acari as a group from the soil became accurate enough to make quantitative comparisons possible in Europe and adjacent countries, it became clear that there was a significant difference in size between Acari populations that were collected at various times of the year. Systematic sampling soon showed consistent seasonal variations in the population densities of this group. The results that were obtained varied somewhat; STÖCKLI (1957) found peak population densities for the Acari during the summer months in Switzerland, DHILLON & GIBSON (1962) obtained similar results in grassland at Headley hall in England but WEIS-FOGH (1948), van der DRIFT (1951), STRENZKE (1952), EVANS (1955) and EVANS *et al.* (1961) recorded the highest population densities during winter months.

In South Africa Ryke (1965) and Olivier & Ryke (1967) found the Acari in kikuyu pasture soil near Potchefstroom to have high winter population densities and low summer population densities. At the same time, howe-

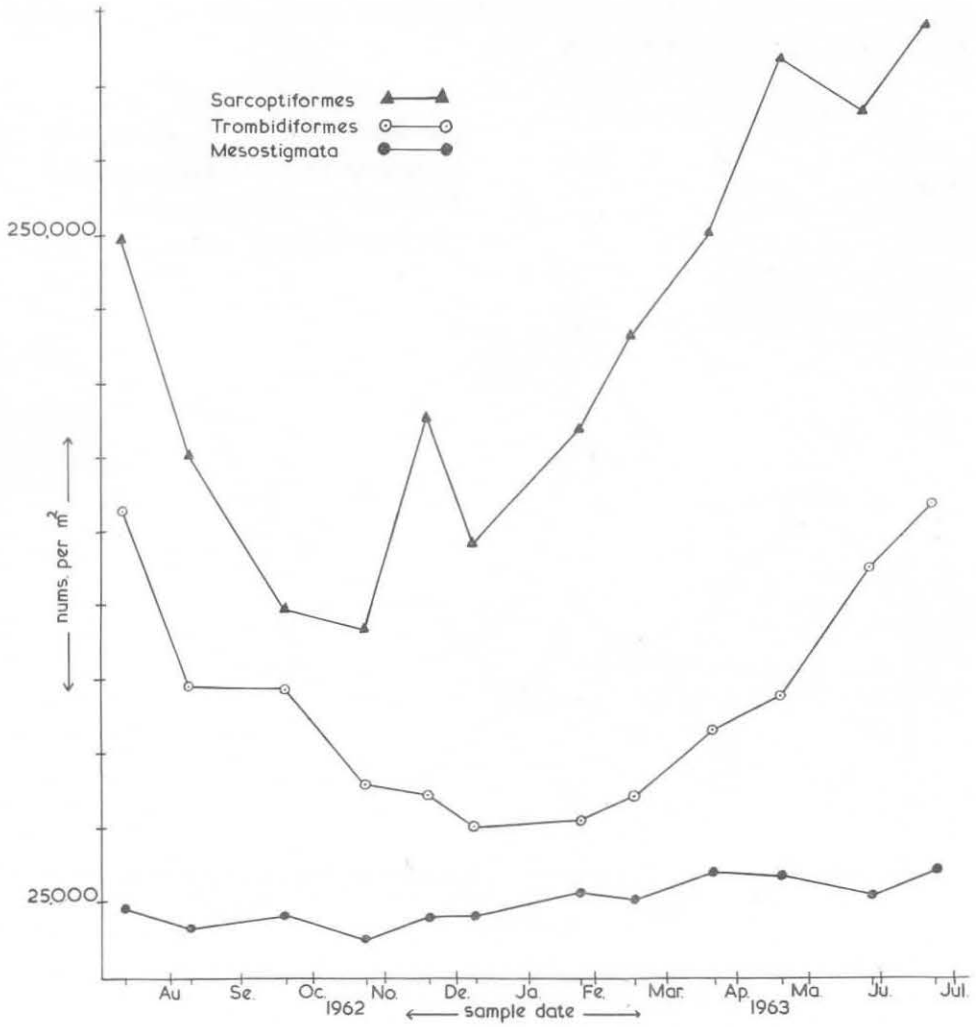

Fig. 11 — Population density variation of Acari groups in Magoebaskloof evergreen forest soils

ver, Loots and Ryke (1966) found the Acari in a *Themeda-Elyonurus* pasture soil, near the kikuyu pasture soil, to have high summer population densities and low winter population densities.

The seasonal population variations that were recorded for the Acari groups in the Magoebaskloof forest soils are shown in fig. 11. Generally, the pattern is the same as that which has been recorded for forests in England by EVANS *et al.* (1961) and in Holland by van der DRIFT (1951) where high population densities are developed in the winter months and low population densities in the summer months.

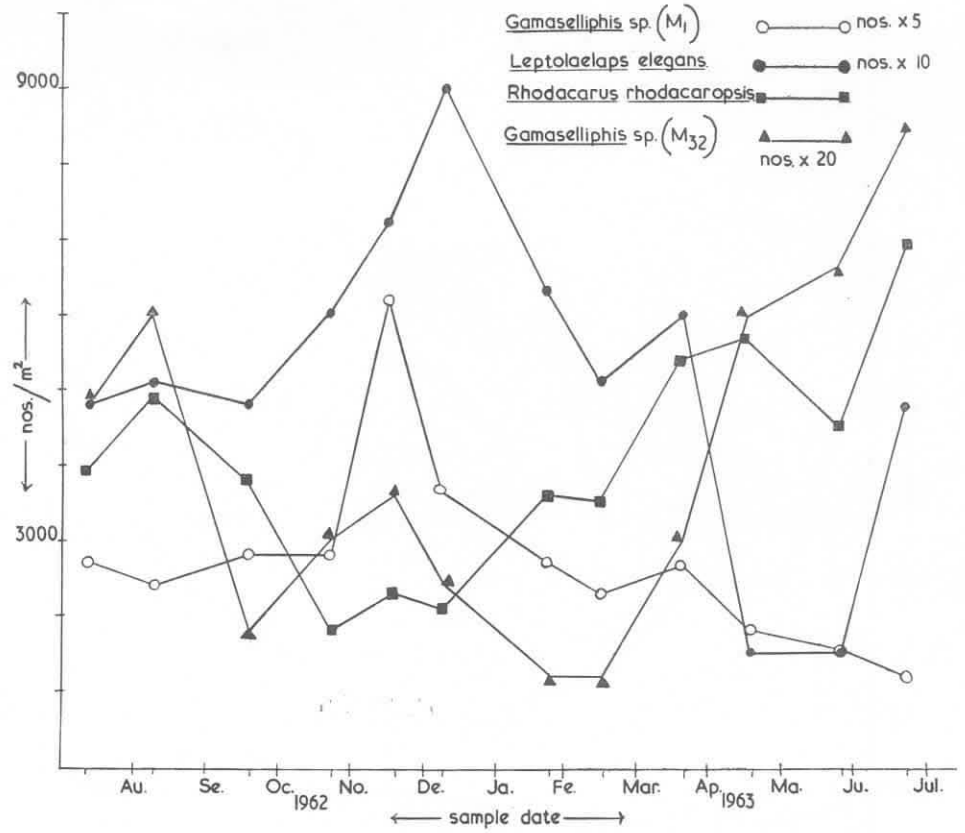

Fig. 12 — Seasonal fluctuations in population densities of 4 species in Magoebaskloof forest soils, sample depth 15 cm

KARG (1961) and DHILLON & GIBSON (1962) have recorded the seasonal population density variations of single mite species, but generally research workers have recorded results for the Acari as a group or its orders only. In the Magoebaskloof forest soils some interesting results were obtained when the authors tried to work out the seasonal population density variations for all

the different species of the Mesostigmata that were encountered. Some population density variations are illustrated in figs. 12, 13 & 14.

The Mesostigmata in the Magoebaskloof forest soil show two types of population density seasonal variations. One pattern shows maximum population densities in the winter months and low population densities in spring and

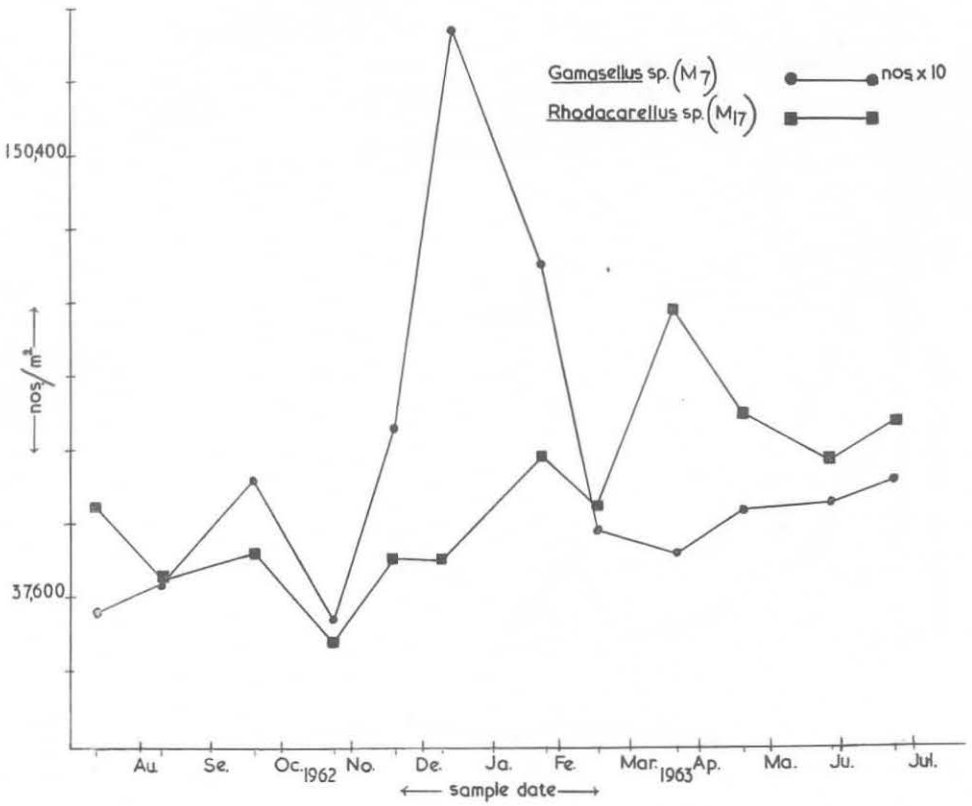

Fig. 13 — Seasonal fluctuations in population desities of two species in Magoebaskloof forest soils, sample depth 15 cm

early summer months. Mites such as, for example, *Rhodacarellus* sp. (M 17) and *Rhodacarus rhodacaropsis* (figs. 12 & 13) show such a pattern. The majority of Acari species in the Magoebaskloof forest soil should show this pattern, because the Acari as a group show this pattern. In contrast to this seasonal population density variation pattern, however, mites such as *Gamasellus* sp. (M 7) and *Leptolaelaps elegans* have high population densities in the summer months and low population densities in the winter months

(figs. 12 & 13). The majority of species in the families Rhodacaridae and Aceosejidae should show this pattern in Magoebaskloof because these families also show the same pattern.

The species of the family Rhodacaridae were found to show both high and low winter population densities. This is probably one important reason

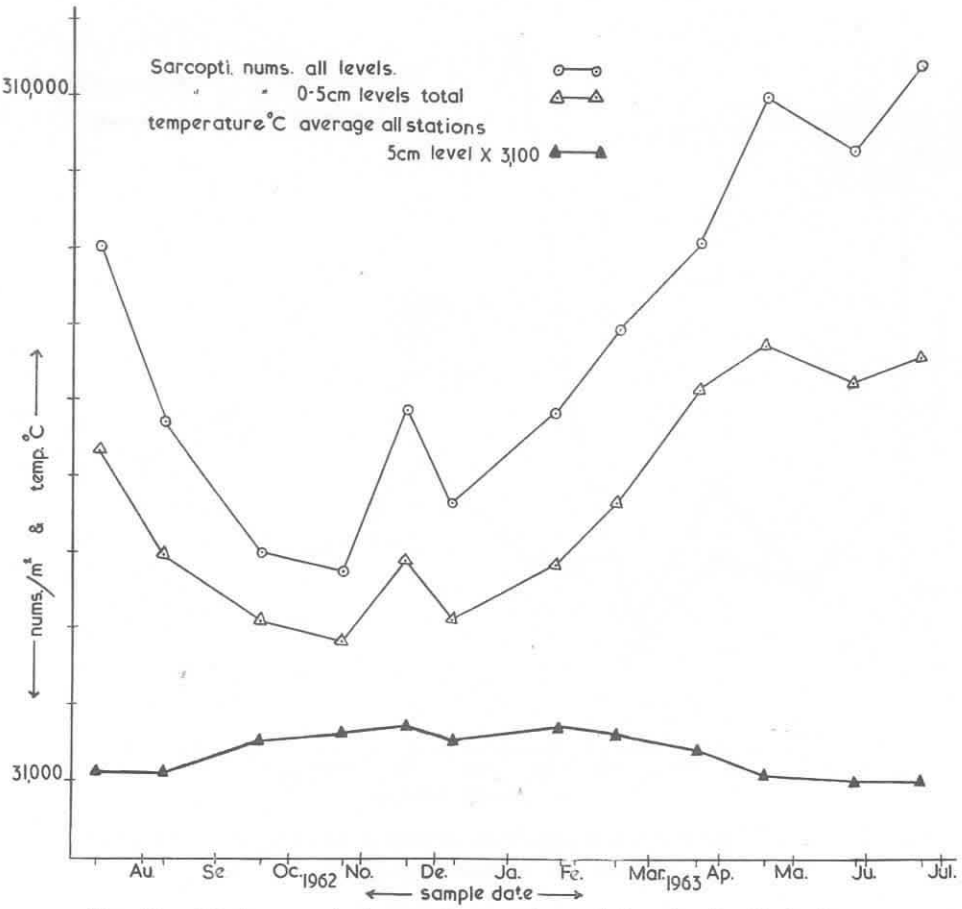

Fig. 14 — *Rhodacarus rhodacaropsis* annual population density fluctuations

why the seasonal variation curve for the family Rhodacaridae has such an irregular shape with peaks in September, December and July besides the main peak in February. Groups of mites such as orders and families can, therefore, show different patterns of seasonal population density variations in different habitats. The actual pattern for a habitat will depend on the species in the

group at the habitat; if the majority of the species show a high winter population density the group as such will show it, and vice versa.

It will be interesting to know whether the density variation pattern of a particular species is the same in two ecologically different habitats. The three species *L. elegans, A. aethiopica* and *R. sublapideus* which were found to be common to the Potchefstroom pasture soils and Magoebaskloof forest soil were unfortunately collected in too low numbers in the pasture soils to be able to see definite patterns for these mites in the latter soils and to make a comparison with the forest soil possible.

4.10. INTERSPECIES COMPETITION

HURLBUTT (1964) and GIFFORD (1964) have found indications that in the genus *Veigaia*, interspecies competition is probably reduced by different vertical distributions of similarly structured species. In the Magoebaskloof forest soils the same phenomenon was encountered, for example, the two species *Gamasellus* sp. (M 34) and *Gamasellus* sp. (M 43) are structurally closely related and occur in more or less the same numbers in the soil, but *Gamasellus* sp. (M 34) is more an inhabitant of the upper 0-5 cm layer of the soil, whereas *Gamasellus* sp. (M 43) is more an inhabitant of the deeper 5-10 cm layer (table 12). Interspecific competition obviously may not only be reduced by differences in habitat of organisms but also other factors, such as, for example, different distributions in time and different food requirements. It is possible that in the Magoebaskloof soils two species of *Gamaselliphis* viz. *Gamaselliphis* sp. (M 1) and *Gamaselliphis* sp. (M 32) illustrate an instance where interspecific competition in the same habitat is eliminated by a difference in distribution in time. Structurally the two species are very similar, differing mainly in setal shape and chaetotaxy; both species prefer the upper soil layer (0-5 cm) but whereas *Gamaselliphis* sp. (M 1) has its highest population density in the summer months, *Gamaselliphis* sp. (M 32) reaches its peak during winter (fig. 12). This latter phenomenon is probably an indication why the two types of distribution — summer or winter maximum population densities — are found among the Mesostigmata species; competition probably not only occurs between taxonomically related species but amongst all species which have the same habitat, the same food preferences and similar biological needs in common.

4.11. TRUE SOIL DEWELLERS AND MIGRANTS

An examination of table 12 shows that certain species of the Mesostigmata have been found in the soil samples very frequently, and both in surface and deep layers; we may assume that these forms are the true soil dwelling (euedaptic) Mesostigmata. They are the following:

Gamaselliphis sp.	(M 1)
Gamasellus sp.	(M 7)
Gamasellus sp.	(M 16)
Gamasiphis sp.	(M 15)
Rhodacarellus sp.	(M 17)
Rhodacarus rhodacaropsis	(M 18)
Asca aethiopica	(M 27)
Leptolaelaps elegans	(M 26)

and certain species of the Uropodina. In contrast to these mites, however, some were only found on the surface and then only rarely. *Macrocheles* sp. (M 36) falls in this category. It is probable that mites such as this species are not true soil dwelling forms but were captured while migrating from on habitat to another. However, much more information is necessary before it will be possible to diferentiate clearly the Mesostigmata into categories such as these.

4.12. BIOMASS OF ACARI

Table 14 shows the weight of certain mites, and the weight of representative groups of the Acari that were collected in the Magoebaskloof forest soils. OLIVIER & RYKE (1967) weighed representatives of the mesofaunal species which they collected in the kikuyu pasture soil near Potchefstroom and give a comprehensive list of the weights of the living organisms for that particular habitat. Biomass figures for the mite species present in the *Themeda-Elyonurus* pasture (excluding those which were collected in the kikuyu pasture soil) are recorded by LOOTS & RYKE (1966). For the two species that were found to be common to the forest soils and pasture soils the following weights were recorded:

	Magoesbaskloof forest soil dead weight (in alcohol).	Potchefstroom pasture soil living weight.
Asca aethiopica	0.017 mg	0.0050 mg
Leptolaelaps elegans	0.0660 mg	0.050 mg

The dead animals are heavier than the live animals as a result of the preservative which penetrated their bodies. In comparing biomass figures which were obtained with different techniques it must therefore be borne in mind that different results may be obtained depending on the technique that is being used for determining the weights.

TABLE 14 — **Weight of certain mite groups and species**
Weight in millionths of a gram

Material weighed	Number weighed	Weight
Sarcoptiformes group of 710 mites from forest soil sample, d 8 cm, height 5 cm	710	14,512
Trombidiformes group of 627 mites from forest soil sample, d 8 cm, height 5 cm	627	1,907
Mesostigmata group of 120 mites from forest soil sample, d 8 cm, height 5 cm	120	2,612
Biomass of above-mentioned groups per m^2		
Cryptostigmata 2,728,200		
Mesostigmata 491,130		
Prostigmata 358,460		

Material weighed	Number weighed	Average Weight for one
Trombidiformes		
Tydeus sp.	20	0.4
Eupodes sp.	20	5.0
Scutacaridae spp.	20	10.0
Cunaxidae spp.	20	9.0
Erythraeidae spp. (big)	20	511.0
Mesostigmata		
Gamaselliphis sp. (M1)	20	32
Gamasellus natalensis	20	58
Gamasellus sp (M3)	20	46
Gamasellus sp. (M7)	20	69
Gamasellus sp. (M16)	20	17
Rhodacarellus sp. (M17)	20	14
Rhodacarus rhodacaropsis	20	13
Leptolaelaps elegans	20	66
Asca aethiopica	20	17
Sejus sp. (M10)	20	18

In the Magoebaskloof forest soil both the heaviest and lightest mites were found among the Trombidiformes in the families Erythraeidae and Tydeidae (*Tydeus* sp.) respectively. In the Sarcoptiformes as well as the Mesostigmata some fairly large mites were also encountered, but it is difficult to say in which group the species are on the average the largest. If representative samples of the three groups are compared, however, as they occur in the soil, also with the same population density as in the soil, then the order of importance in terms of highest mass is:

1st	Cryptostigmata	(710	mites)	with	a	mass	of	14,512	millionths	of	a	gram
2nd	Mesostigmata	(120	»)	»	»	»	»	2,612	»	»	»	»
3rd	Prostigmata	(627	»)	»	»	»	»	1,907	»	»	»	»

If only numbers are taken into account, the Prostigmata and Mesostigmata change positions. The family Tydeidae, which are on the whole very small and light mites, contribute in numbers a large proportion of the 627 mites and that is probably the reason why the Prostigmata as a group, although more in numbers, is lighter than the Mesostigmata.

On comparing the weight of the species of the Mesostigmata (table 14) with their vertical distribution (table 12) it is interesting to note that the heaviest mites, *Gamasellus* sp. (M 7), *Gamasellus natalenss, Gamaselliphis* sp. (M 1) and *Leptolaelaps elegans,* are surface inhabitants, whereas the lighter species such as *Rhodacarellus* sp. (M 17) and *Rhodacarus rhodacaropsis* live in the deeper layers. HAARLOV (1955) investigating the vertical distribution of Acari and Collembola in relation to soil structure, including *Veigaia serrata,* found for certain Acari a correlation between the size (in terms of lengths) of the mites and the soil layer which they inhabited; small and large mites were found in the surface layers but there was a tendency for only small mites to live in the deep layers, a phenomenon which could be correlated with the fact that in the deeper layers, the cavities available for habitation were smaller than those in the more superficial layers.

The relation between size and numbers that has been illustrated by LAWRENCE (1953) and GHILAROV (1944) is also shown by the Magoebaskloof Acari. Using weight to indicate size and referring to table 14 and tables 4 & 6-8, it is clear that the lightest mites are the most numerous; of the Trombidiformes, the Tydeidae are the most numerous in the soils but they are also the lightest. In the Mesostigmata group, *Rhodacarellus* sp. (M 17) has the highest population density and it is the second lightest species of this order that was weighed.

In the introduction section it was pointed out that the biomass of a group of animals is a much better indication of its biological activity in a habitat than its population density and that its energy consumption is an even better measure of biological importance. Using biomass and energy consumption of the Acari as standards for measurement, OLIVIER & RYKE (1967) found some interesting results in the Potchefstroom kikuyu pasture soils. In the Potchefstroom pasture soils seasonal fluctuations in numbers on comparison generally were found to be paralleled by fluctuations in biomass but in a few instances the biomass concept upset some of the deductions that were based on population densities only; for example, although the Rhodacaridae were numerically dominant in the kikuyu pasture soil, the Laelaptidae were dominant with reference to biomass.

With reference to energy consumption, OLIVIER & RYKE (1967) found that in August 1963 the Mesostigmata consumed 6,754 calories per m^2 of soil in contrast to the Oribatei which only consumed 3,105 calores per m^2; but, with reference to numbers, the Oribatei had a population density of 23,092 per m^2 and the Mesostigmata only 2,650 per m^2. Therefore, although they were considerably fewer in numbers than the Oribatei, the Mesostigmata consumed more than twice the amount of energy than the Oribatei. It is obvious that together with their population densities, the efficiency of an animal group in consuming energy must also be taken into account if worthwhile ecological ranks of importance are to be worked out. At present the methods for estimating energy consumption of soil microarthropods involve cumbersome techniques and many assumptions and approximations in the calculations but results such as those quoted above for the Oribatei and Mesostigmata show that it is necessary that more refined and accurate techniques should be developed for determinations of energy consumption in soil habitats.

4.13. SOME ECOLOGICAL CHARACTERISTIC FEATURES OF THE MESOSTIGMATID SPECIES THAT WERE ENCOUNTERED IN THE MAGOEBASKLOOF FOREST SOILS

Family Rhodacaridae

Gamaselliphis spec. nov. (M 1)

This mite is an inhabitant of the litter of forest soils and for the greater part of the period August 1962 to July 1963, it was found only in the 0-5 cm layer of the forest soil. During the months January and February 1963,

it was found in small numbers in the 5-10 cm layer. The other species of the genus *Gamaselliphis* which have been described in South Africa (RYKE, 1961), have all been found in soils, and two of these were found in the Natal evergreen forests which resemble the Magoebaskloof forests very closely. *Gamaselliphis* sp. (M 1) was found abundantly at all the collecting stations in both the Magoebaskloof evergreen forests and the pine plantations. In the evergreen forests it was more abundant than *Gamaselliphis* sp. (M 32) but in the pine plantations these two species had comparable population densities. In the exergreen forests *Gamaselliphis* sp. (M 1) was found in 90 % of the 0-5 cm layer samples, and in the pine plantations in 96 % of the comparable samples.

The highest population density of *Gamaselliphis* sp. (M 1) was recorded in the summer months and the lowest in the winter months, and in so doing it probably avoids interspecies competition with *Gamaselliphis* sp. (M 32) which had its population density peaks in winter and the minima in the summer months. The maximum density that was recorded for *Gamaselliphis* sp. (M 1) in the 0-5 cm soil layer was 2,068 per m^2 in the natural forest, and 2,256 per m^2 in the pine plantations. The distribution of this species was too irregular to be able to calculate its colony size with the aid of the Hughes paired sampling technique. Eleven individuals was the highest number that was encountered in samples with a diameter of 8 cm and a height of 5 cm; the most common grouping together was one to four individuals. Twenty average sized adults were weighed and the average weight for one individual was found to be 32.3 millionths of a gram.

Gamaselliphis spec. nov. (M 32).

This species resembles *Gamaselliphis* sp. (M 1) structurally. It was a litter inhabitant, was mainly found in the 0-5 cm layer of the soil but occasionally penetrated into the 5-10 cm layer. The mite was found at all the collecting stations in Magoebaskloof, and was only slightly less numerous than *Gamaselliphis* sp. (M 1) in the pine plantations. In the evergreen forests, it was found in 23 % of the 0-5 cm layer samples but in the pine plantations in 66 % of the comparable samples.

Gamaselliphis sp. (M 32) had its peak population density in the winter months and its lowest in the summer months. The highest density recorded was 1,128 individuals per m^2 in natural forest and 1,785 per m^2 in pine plantations in the 0-5 cm layer of the soil. Because of its very irregular distribution it was not possible to calculate the colony size of the mite.

Gamaselliphis spec. nov. (M 36).

This species is much smaller than the other two *Gamaselliphis* species that were found in the Magoebaskloof forest soils. Similarly to the other two

species, *Gamaselliphis* sp. (M 38) was a surface layer inhabitant which only occasionally penetrated into the deeper layers; in contrast to the other two species it was also found in the 10-15 cm soil layer; its smaller size probably facilitated its greater depth penetration ability. It was found at all the collecting stations in Magoebaskloof.

The highest population density that was recorded was 4,136 individuals per m^2 in the 0-5 cm layer of the natural forest. It was found less frequently than the other two species, viz, only in 55 % of the 0-5 cm layer samples of the natural forest and 9 % of the pine plantation samples.

Gamasellus natalensis RYKE 1962.

This species which is also known in the Natal Forests, was mainly an inhabitant of the 0-5 cm layer in the Magoebaskloof forest soils, but occasionally it was collected even from the 10-15 cm layer. *Gamasellus natalensis* was found at all the collecting stations in the Magoebaskloof forests, and at station A occurred in 72.5 % of the 0.5 cm layer paired samples, in which it also achieved a population density of 2,790 individuals per m^2.

An attempt was made to work out the colony sizes with the aid of the Hughes technique from the paired samples; however, the majority of the colonies appeared to have a radius smaller than 5 cm, making the Hughes technique inapplicable to these because of the short tie line that must be used (see table 11). The biggest colony size was estimated to be 9.5 cm in radius, containing one to four individuals and there were 23 such colonies in an area 3 m by 1.5 m at station A.

The annual variations in population density are small and it is not possible to say at what time of the year maximum population densities are developed.

Twenty adults were weighed and the average weight per individual was estimated to be 58 millionths of a gram.

Gamasellus spec. nov. (M 3).

This mite was collected at all the collecting stations in the Magoebaskloof forests, where it was found mainly in the 0-5 cm layer of the soil, occurring only occasionally in the 5-10 cm layer.

Gamasellus sp. (M 3) was found in 51 % of the 0.5 cm layer soil samples of the natural forest and in 18 % of the pine plantation samples. It achieved a maximum population density of 2,820 per m^2 (5 cm deep samples in natural forest). Maximum population densities were recorded in the summer months.

Gamasellus nkandhlaensis RYKE 1962.

This mite was collected by Lawrence in the Nkandhla forests (offshoots of the Drakensberg series) in Natal in 1940. Only seven adult specimens were collected in the quantitative samples of the Magoebaskloof evergreen

forest soils so that nothing more can be added to what is already known about the biology of this mite.

Gamasellus spec. nov. wM 7).

Up to 87 % of the 0-5 cm layer evergreen forest soil samples contained this species and it was encountered at all the collecting stations. The highest population densities were recorded in the summer months, as many as 4,234 per m^2 in the 0-5 cm soil layer of the natural forests. This mite was mainly an inhabitant of the 0.5 cm layer of the soil but it penetrated in small numbers into the 10-15 cm layer, mostly in the summer months.

With the aid of the Hughes paired sampling technique, the colony sizes and distribution of this mite were estimated. Although as many as 26 individuals were collected in a soil sample (radius 3.2 cm and height 5 cm) the most frequently occurring group size was a group of one to four individuals and these colonies had a radius of 9.3 cm. The biggest colony was estimated to have a radius of 10 cm and colonies such as this one were found to be made up of five to nine individuals.

Twenty individuals of this species were weighed and the average weight per individual was estimated to be 69 millionths of a gram.

Gamasellus spec. nov. (M 16).

Gamasellus sp. (M 16) was one of the characteristic mesostigmatid species of the Magoebaskloof evergreen forest soil. It was found at all the collecting stations and it occurred in 95 % of the 0-5 cm layer paired samples and in 83 % of the subsample series. The mite was mainly a surface layer inhabitant but also occurred in the 5-10 cm and 10-15 cm soil layers in considerable numbers. A maximum population density of 11,160 per m^2 was recorded in the paired sample series in the natural forests. Maximum population densities were recorded in the summer months.

It is a fairly small mite; twenty specimens were weighed and the average weight per individual was estimated to be 17 millionths of a gram. Not only are the mites themselves small in size, but the colony radii were also relatively small, the majority of colonies had a radius smaller than 5 cm (table 11). The biggest colonies, those containing one to four individuals, had a radius of 14.28 cm, and there were 31 such colonies in an area 3 m by 1.5 m at station A.

Gamasellus spec. nov. (M 34).

This mite was collected at all the collecting stations in Magoebaskloof, it was mainly a 0-5 cm layer inhabitant but was also present in the lower layers in small numbers. It was recorded in as many as 50 % of the 0-5 cm layer paired samples in the natural forest. The highest population densities

were recorded in the winter months, reaching 1,128 per m^2 in the natural forest 0-5 cm soil layer.

Gamasellus spec. nov. (M 43).

Small numbers of this mite were recorded at all the collecting stations in Magoebaskloof. It inhabits mainly the deeper soil layers where it was found in 39 % of the 5-10 cm layer samples in the natural forests; in the surface layer (0-5 cm layer) it was only recorded in 14 % of the samples. The highest population densities were recorded in June (1,692 per m^2) in the 5-10 cm layer of the natural forest soil. The distribution of *Gamasellus* sp. (M 43) was too irregular and the density too low to enable one to deduce anything about its colony sizes.

Gamasellus spec. nov. (M 45).

This mite was collected at all the collecting stations in Magoebaskloof except at station F. Although it is well represented in all the upper soil layers, it prefers the 5-10 cm layer. The soil at station F differs from that of the other stations in being mor-like and in having a much higher clay content and a less acid pH. *Gamasellus* sp. (M 45) therefore apparently prefers a moder-like soil medium and a soil with less clay in it and a less acid environment than that at station F. It was recorded in 40 % of the 5-10 cm layer samples of the subsample series in the natural forests, in 38 % of the 0-5 cm layer and in 22 % of the 10-15 cm layer samples. Population densities as high as 2,256 m^2 in the natural forests were recorded and the highest numbers were collected during the winter months in the 5-10 cm soil layer.

Gamasellus spec. nov. (M 52).

At all the stations this mite was collected mainly in the deeper layers; it was found in only 8 % of the 0-5 cm layer subsample series samples in the natural forests as against 14 % in the 5-10 cm layer and 18 % in the 10-15 cm layer samples. Population densities were relatively low, being 752 per m^2 in the evergreen forests in the 10-15 cm soil layer. The distribution of this mite was so irregular and the population density so low, that nothing could be deduced regarding its colony sizes and dimensions.

Gamasiphis spec. nov. (M 5).

The taxonomy of the *Gamasiphis-Ologamasus* group of genera is under consideration for revision, and this species and the other species that will be mentioned below are only provinsionally referred to the genus *Gamasiphis*.

Gamasiphis sp. (M 5) was collected at all the collecting stations in Magoebaskloof and was found to be mainly an inhabitant of the 0-5 cm soil layer. mainly in the winter months, but the distribution of this mite was so irregular and the population density so low, that very little can be deduced from the available data.

Gamasiphis spec. nov. (M 15).

This species was collected at all the collecting stations in Magoebaskloof and although its presence was recorded in all the soil layers investigated, its highest population densities were found to occur in the 0-5 cm soil layer; the peaks were recorded in the winter months, reaching as many as 1,880 per m^2 in the natural forest samples; 58 % of the 0-5 cm subsample series samples contained this species. The low population density and the irregular distribution in the paired sample series rendered it impossible to define the sizes and dimensions of the colonies.

Rhodacarellus spec. nov. (M 17).

Rhodacarellus sp. (M 17) was collected at all the collecting stations in Magoebaskloof. Ninety-three per cent of the paired samples contained the mite and a population density of 19,140 individuals per m^2 was recorded in the 5-10 cm soil layer. In the pine plantations only 30 % of the samples yielded specimens of this mite and a maximum of only 226 per m^2 was recorded. The highest population densities were found in the months of May and July (figure 13). Although very numerous in the 0-5 cm layer of the natural forest, 88 % of the 5-10 cm layer samples contained the mite and 86 % of the 10-15 cm layer, as against 80 % in the 0-5 cm layer; at a depth of 1 m the mite was still frequently encountered (table 13).

With the aid of the Hughes paired sampling technique, the colony radii and aggregate sizes were determined. In a slab of soil 3 m by 1.5 m and 5 cm deep at station A, there were 23 colonies of one to four individuals with an average radius of 19.1 cm, 25 colonies of five to nine individuals with an average radius of 19.1 cm, 25 colonies of five to nine individuals with an average radius of 15.2 cm, 31 colonies with an average radius of 10 cm and 10 to 14 individuals, and 22 colonies with the same diameter but with 15 to 19 individuals constituting the colony. The other colonies all had a radius smaller than half the distance of the tie line that was used in the technique, that is, smaller than 5 cm (table 11).

Rhodacarus rhodacaropsis RYKE 1962.

This species, which was collected at all the collecting stations in Magoebaskloof, apparently has a wide distribution in South Africa. It was collected, for the first time, in humus under trees on a river bank at Potchefstroom in what is, climatologically and topographically speaking, a very different habitat from that of the Magoebaskloof forest soils.

It frequents all the soil layers (0-15 cm), but has a slight preference for the 5-10 cm layer. Ninety-five per cent of the samples of the natural forest 5-10 cm soil layer contained this species, whereas in the 10-15 cm and 0-5 cm

layers the relevant figures were 89 % and 93 % respectively. At the 1 m level it was found in much higher population densities than any of the other Mesostigmata (table 13). Their numbers reached as many as 7,332 per m^2 in the natural forests and the highest densities were recorded in the winter months in the 5-10 cm soil layer (fig. 14).

It was the lightest mesostigmatid mite that was weighed; 20 individuals were weighed and the average weight per individual was estimated to be 13 millionths of a gram.

The population density of this mite in the paired sample series was too low, and the distribution too irregular, to be able to estimate the colony sizes and dimensions.

Rhodacarus sublapideus RYKE 1962.

This mite was collected in the surface layers at some of the collecting stations in the Magoebaskloof forest soils. The distribution of this species is, however, too irregular and its population densities too low to allow the deduction of worthwhile information from the numbers that were collected. The mite must have a wide distribution; it was collected at Potchefstroom for the first time from soil in a termite's nest under a stone.

Digamasellus spec. nov. (M 19).

This mite was collected in the summer months but only in three samples, so that very little could be deduced about its ecology.

Family Laelaptidae.

Leptolaelaps elegans Berlese 1918.

This mite was collected at all the collecting stations in Magoebaskloof. It is widely distributed in South Africa, having already been collected in Zululand, Natal, and Potchefstroom and Boskop in the Transvaal. In the Magoebaskloof natural forests it occurred in 70 % of the 0-5 cm layer sub-sample series samples, in 36 % of the 5-10 cm samples and in only 12 % of the 10-15 cm samples.

A maximum population density of 1,504 individuals per m^2 was recorded in the 0-5 cm layer of the natural forests; maximum population densities occurred in the summer months. With the aid of the Hughes paired sampling technique, some of the colony sizes and dimensions were estimated. This species is apparently not very gregarious, the colonies mainly contain from one to four individuals (table 11) and there were 26 such colonies in a soil slab 3 m by 1.5 m and 5 cm deep at station A. The average radius of these colonies was 19 cm.

The mites are relatively big; according to RYKE (1963) the length of the idiosoma is 480-654 microns. Twenty adults of this species were weighed and the average weight per individual was estimated to be 66 millionths of a gram.

Family Aceosejidae.

Asca aethiopica

This species which is a 0-5 cm soil layer inhabitant was collected at all the collecting stations except station F, perhaps for the same reasons as suggested for *Gamasellus* sp. (M 45). It is possible that *A. aethiopica* has a very wide distribution in South Africa. It has been found around Potchefstroom in a variety of habitats and now also in forest soils at Magoebaskloof. Specimens were collected from 60 % of the 0-5 cm layer subsample series in the natural forest, and a maximum population density of 4,512 individuals per m^2 was recorded; the highest numbers were present in the summer months.

Twenty individuals were weighed and the average weight per individual was estimated to be 17 millionths of a gram. The population density of this mite in the paired samples was too low, and the distribution too irregular to be able to deduce anything about its colony sizes and dimensions.

The Uropodina group

Four species of the Uropodina were collected, but because of taxonomic dificulties, it was not determined to the genus or species levels.

These four species were collected at all the stations in Magoebaskloof where some of them reached population densities of 5,452 per m^2 in the 0-5 cm soil layer of the natural forest.

Some mites were collected in such small numbers that the information which could be deduced from the collections was very limited. The following mites belong to this category:

Family Rhodacaridae

Gamasiphis spec. nov. (M 33).
Gamasellodes spec. nov. (M 41) — mainly a surface layer inhabitant.
Notogamasellus spec. nov. (M 48) — mainly a sub-surface layer inhabitant.
Gamasellopsis spec. nov. (M 44A).
Gamasellopsis spec. nov. (M 44B).

Family Aceosejidae

Sejus spec. nov. (M 8) — mainly a surface layer inhabitant.
Plesiosejus spec. nov. (M 10) — mainly a surface layer inhabitant but penetrates into the deeper layers in December and January.
Proctolaelaps spec. nov. (M 11) — mainly a surface layer inhabitant; maximum population densities in summer.
Lasiosejus spec. nov. (M 14) — mainly a surface layer inhabitant.
Asca spec. nov. (M 37) — mainly a surface layer inhabitant.
Iphidozercon spec. nov. (M 39) — mainly a surface layer inhabitant; maximum population densities in summer.

Family Laelaptidae

Cosmolaelaps spec. nov. (M 29).
Gaeolaelaps spec. nov. (M 42) — high population densities in pine plantations; low population densities in evergreen forests.
Hypoaspis speculifer.

Family Macrochelidae

Holostaspella spec. nov. (M 30) — mainly a surface layer inhabitant.
Macrocheles spec. nov. (M 36).

Family Veigaiaidae

Veigaia nemorensis — mainly a surface layer inhabitant; it has a higher population density in the pine plantations than in the evergreen forests; a world wide distribution.
Gorirossia whartoni — mainly a surface layer inhabitant; a world wide distribution.

Family Pachylaelaptidae

Pachylaelaps spec. nov. (M 12) — mainly a surface layer inhabitant; a very large mite.
Pachylaelaps spec. nov. (M 13).
Pachylaelaps spec. nov. (M 35) — mainly a surface layer inhabitant.
Parasitidae nymphs (M 21) — mainly surface layer inhabitants.

Trachytidae sp. (M 9).
Phytoseiidae spp. (M 28).

In the Magoebaskloof evergreen forest soils, the characteristic mesostigmatid species association was found to be:

Rhodacarus rhodacaropsis
Rhodacarellus sp. (M 17)
Gamasellus sp. (M 16)
Gamasellus sp. (M 7)
Gamaselliphis sp. (M 1)
Leptolaelaps elegans and
Asca aethiopica

These mites are, with reference to numbers and distribution frequencies, the dominant Mesostigmata.

5. CHANGES IN THE ACARI POPULATION OF THE MAGOEBASKLOOF FOREST SOIL COMMUNITY

5.1. GENERAL

Soil communities have not yet been studied well enough to show oscillations in their species composition, but violent oscillations in population densities have been witnessed. These oscillations are probably the result of the self propagating, self limiting and self regulating mechanisms which are in action in the communities. These mechanisms, we may also assume, may vary in complexity; some may be composed of a single factorial component whereas others may be formed from a large number of components.

In this work an attempt was made to identify some of the components in the regulating mechanisms of the mite portion of the animal community in forest soils which could cause the oscillations in their population densities. An attempt was also made to identify some of the factors which may determine the absence or presence of a particular species in a certain habitat. In the previous section, section 4, some density dependent factors affecting population density, such as interspecies competition, were briefly considered. In this section the authors wish to deal mainly with density independent factors. MACFADYEN (1963) discusses the concepts «density dependent factors» and «density independent factors» as factors affecting population density oscillations.

5.2. EFECT OF SOIL WATER CONTENT ON ACARI

TRÄGARDH (1928) records that mites prefer damp conditions. He found higher population densities in damp habitats than in dry ones. HAMMER (1937, 1944) found species differences between the mite faunas of dry habitats and damp habitats, and concluded that some mites preferred dry conditions whilst others preferred damp conditions and that soil humidity ranks first in determining the absence or presence of mite species in the biotopes she studied. KÜHNELT (1961) associates characteristic faunas with the various degrees of wetness and is of the opinion that not only is degree of wetness important, but also the duration of the wetting of the substrate; he found that the number of species in litter layers which dry out occasionally was fewer than in those layers which remained permanently moist but not water logged; also that constantly wet soil pore spaces wich are, however, filled predominantly with air, harbour the fauna richest in species and individuals. In the lower layers of soils of this latter type, he found species of *Rhodacarus*, *Scutacarus* and *Oppia* to be common, provided the subsoil was not very sandy or of heavy clay.

From the work of, for example, THAMDRUP (1939), HARTENSTEIN (1962 B & C) and WHARTON (1963), it has become clear that for the soil inhabiting Acari water may be important for the following reasons:

(a) The amount of soil water in the inter-soil particle spaces determines the relative humidity of the air in the spaces. Edaphic Acari are unable to control very efficiently the loss of water through their cuticles, and if they come into an atmosphere in which the relative humidity of the air is very low so that the air has a desiccating effect they lose water through their cuticles and may be desiccated to death. This effect is seen, when mites such as, for example, *Rhodacarus* spp. and *Rhodacarellus* spp. are being weighed on a very sensitive balance. If left exposed to an atmospheric relative humidity of 55 % (temperature 22° C) they continually lose weight until they have shrivelled up completely. A certain amount of soil water is therefore necessary to keep the relative humidity of the air in the soil spaces above that level at which it will have a desiccating effect. KEVAN (1962), however, pointed out that one should guard against assuming conditions to be too dry below ground level merely because they are so above the ground. THAMDRUP (1939), for example, found that in Danish heathland, even under severe drought conditions, the relative humidity of the soil air rarely fell below 90 %, a moisture content of 10-20 % (dry matter and water = 100 %) was found to correspond to a relative humidity of 75-90 %. The desiccating factor the-

refore only becomes important when the soil water content falls to a very low level. From the work of WHARTON (1963) on equilibrium humidities, it is clear that for some mites the desiccating conditions must be fairly prolonged because if these mites are exposed to a relative humidity above their equilibrium humidities, they may be able to make good their water losses by active

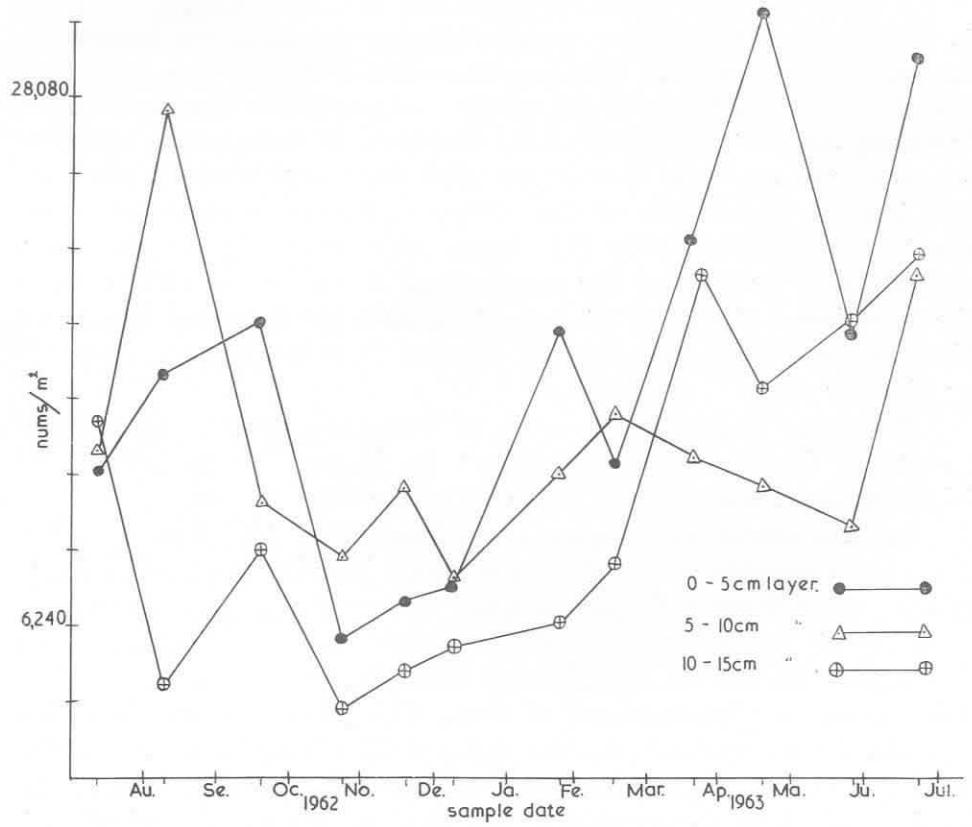

Fig. 15 — Sarcoptiformes annual variation in numbers and water content annual variation

intake of water from the atmosphere. WINSTON (1964) gives a general discussion of the physiology of water balance in mites and ticks.

(b) The soil Acari are all air breathing organisms and if the air spaces in which they live become filled with water, they will drown. However, according to KEVAN (1962), the mesofauna is frequently unaffected by excess water, not as a result of any special physiological adaptation, but simply

because the small soil spaces in which they live only become partially water filled. The soil spaces are very irregularly shaped and bubbles of air are trapped around the organisms. Water floods passing over the soil or through the soil may, therefore, not have a very marked drowning effect. If, however, the water table rises to the surface layers, all the air may be expelled, causing the mites to drown.

(c) HARTENSTEIN (1962 B) found that many individuals in a culture of *Belba* sp. died because they became immobilized by surface tension against the sides of the culture dish in which they were kept. KEVAN (1962) is of the opinion that surface tension is an important enemy of soil arthropods in soil spaces because of its immobilization possibilities. Very little quantitative data are, however, available on this aspect and the matter needs investigation.

Relative humidities, floods and surface tension are all factors which may directly affect the soil Acari, but it is also possible for the amount of soil water in a soil to affect the Acari indirectly by way of the food chains. Many mites are herbivorous organisms (EVANS *et al.*, 1961; HARTENSTEIN, 1962), and these mites may be adversely affected if their plant food diminishes because there is not sufficient water in the soil to sustain a normal plant growth.

An attempt was made in this work to find out whether there is any correlation between soil water content changes in the soil and population density changes of the mites in the Magoebaskloof forest soils. Correlations were worked out mainly for the Sarcoptiformes because it was reasoned that this group would most likely be affected by changes in soil water content of the soil as so many of them are herbivorous, and soil water content changes are known to affect the soil microflora.

Figures 4 and 15 show the variations in soil water content in the forest soils and the population densities of the Sarcoptiformes that were measured. The «Bravais-Pearson» equation for correlations was used to calculate the correlation in population density changes with changes in water content. If the percentage water content of the soil was worked out as

$$\frac{\text{weight of water driven off}}{\text{dry weight of soil}} \times 100,$$

a correlation value of 0.01 was obtained. If the percentage water content of the soil was worked out as

$$\frac{\text{weight of water driven off}}{\text{total weight of soil}} \times 100,$$

a correlation value of 0.2 was obtained. These correlation values are very low and it is therefore, extremely doubtful whether there was any correlation between changes in water content of the soil and changes in population density of the Sarcoptiformes, or any other acarine group. This obviously does not mean that water does not affect the Acari at all, but only that changes in population density of the Acari behave independently of changes in the water content, within limits, of the soil in which the Acari live.

5.3. EFECT OF SOIL TEMPERATURE ON ACARI

In forest soils it is difficult, if not impossible, with the techniques at present available, to dissociate the effects of temperature on the soil Acari, from those of other factors in action in the soils. In general it has been shown that temperature has an influence on many of the bigger animals in the soil, for example, the earthworms, but very little is known about the influence of soil temperatures on smaller animals such as the Acari, particularly in forest soils.

Acari and Collembola have been found to be active under a blanket of snow (KEVAN, 1962; KÜHNELT, 1961), and oribatid mites such as *Malaconothrus egregius* have been found to occur in meadow soils and hot spring soils with temperatures up to 41° C. A problem which is worth investigating, therefore, is the temperature tolerance of mites in general, and for species in certain habitats in particular.

Vertical migrations of soil animals have been found in high alpine soils and population density changes have been observed in grassland soils, which possibly correlated with severe winter-summer temperature changes (KÜHNELT, 1961; KEVAN, 1962). Under less extreme conditions, low winter temperatures have been found to penetrate very little into the soil (KÜHNELT, 1961), affecting the fauna to a minor extent; the same will probably apply to very high temperatures. KARPPINEN (1955) found that prolonged temperature and water content changes in some forest soils caused some species of a camisiid population to migrate up and down in accordance with changes in these factors, whilst other species were seemingly unaffected by changes in these factors and migrated vertically in accordance with seasonal changes. These phenomena were only observed in some of the forest soil habitats investigated by Karppinen. Observations have shown that, in general, the greater the seasonal amplitude of surface soil temperature, the greater the depth at which fluctuations are noticeable (LUTZ & CHANDLER, 1959). In the tropical and subtropical rain forests, temperatures are very favourable (DEBOUTTEVILLE, 1951; WEBER, 1959) and, to a lesser extent, the same applies to the

montane forest type to which the Magoebaskloof evergreen forests belong. Figures 5 & 16 show the annual and daily temperature fluctuations in the Magoebaskloof evergreen forest soils; note the slow temperature changes in the soil, the absence of extremes, and little penetration of temperature changes. The annual temperature changes in the Magoebaskloof evergreen forest soils

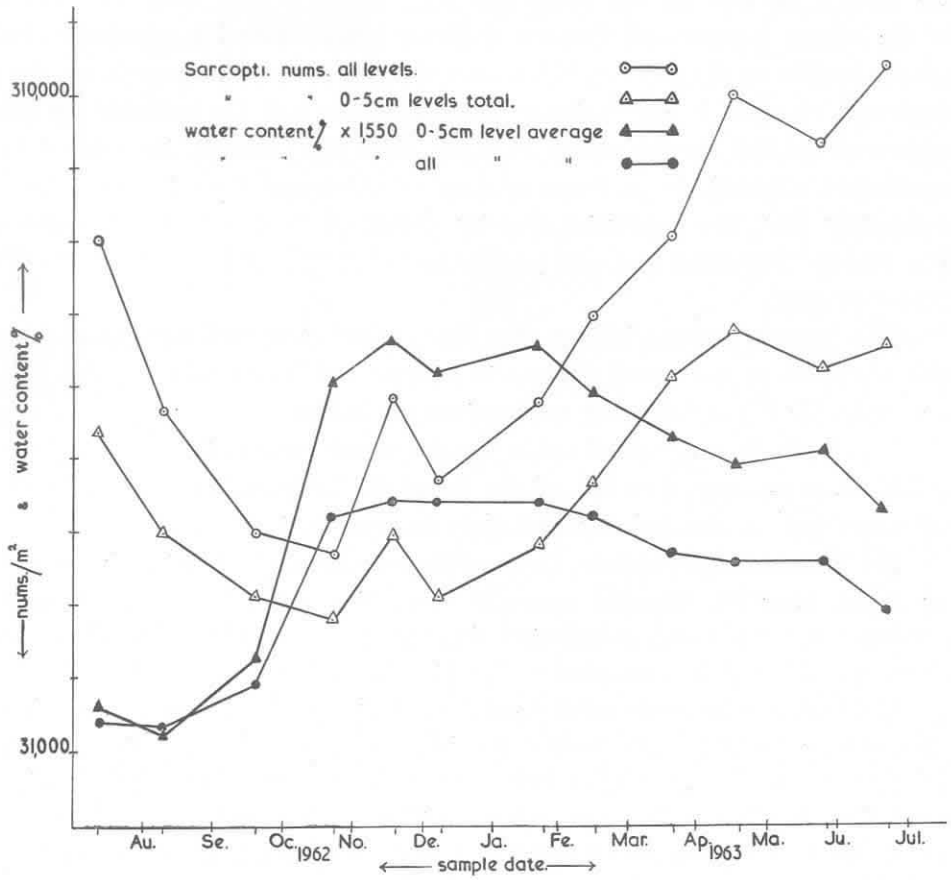

Fig. 16 — Sarcoptiformes annual variation in numbers and temperature annual variation

were compared with the population density changes of the Sarcoptiformes, shown graphically in fig. 16, to see whether there was any correlation. The «Bravais-Pearson» equation for correlations was used, and a value of 0.02 was obtained. This indicates that it is very unlikely that there is any correlation in population density changes of the Sarcoptiformes with the soil temperature changes in Magoebaskloof forest soils.

5.4. WATER CONTENT AND TEMPERATURE THRESHOLD VALUES

LOOTS & RYKE (1966) investigated the possibility of there being a correlation between the Acari population density changes in a *Themeda-Elyonurus pasture* soil, and changes in the moisture content of the soil, as reflected by the amount of rain on the area, and they found a very close correlation. In the kikuyu pasture soil OLIVIER & RYKE (1967) found a correlation, for certain months of the year only, between changes in the mite population densities and changes in the moisture content of the soil (as reflected by the amount of rainfall on the area). In April 1963, for example, they found no correlation; although the moisture content was high and the soil temperatures moderately low, the population density decreased contrary to expectations. The authors suggested that this phenomenon might have been due to inefficient extraction.

The present authors believe that these correlations and non-correlations with temperature and water content in pasture and forest soils (section 5.2) are explicable if the following assumptions are made:

(a) There is a threshold value for the water content in the soil, above which the population densities of the Acari do not react to changes in the soil water content and below which they do react to it.

(b) In favourable habitats, (favourable temperature and moisture content) the Acari have an inherited seasonal population density variation pattern according to which high population densities are normally achieved in the winter months and low population densities in the summer months.

(c) Extreme environmental conditions such as, for example, very low soil moisture contents, can modify the inherited seasonal population density variation pattern in a particular habitat to such an extent that relatively high population densities will occur whenever the environmental conditions are favourable, and low population densities will occur whenever the environmental conditions are unfavourable.

With these assumptions correlations and non-correlations with temperature and soil moisture content in the Magoebaskloof forest soil and Potchefstroom pasture soils can be explained as follows:

In the Magoebaskloof forest soils temperature and moisture conditions are always favourable, temperatures being always above freezing point and never over 22° C; the soil water content may drop to 24 % in the 0.5 cm layer, but 24 % is still above the threshold value for affecting the Acari. (The

average soil water content for the 0-5 cm layer for 12 months was 95 %. S. w. cont. $= \frac{\text{water lost}}{\text{dry weight}} \times 100$). Because conditions were always favourable with reference to temperature and soil water content the Acari did not react to changes in the temperature and soil water content and no correlations were therefore detected between population density changes and changes in temperature and water content in Magoebaskloof. It is, therefore, probable that the observed population density pattern of high numbers in the winter and low numbers in the summer is an inherited pattern in the species in which it is manifested.

In the *Themeda-Elyonurus* pasture soil an environmental factor in the form of soil moisture content had reached an extreme beyond the threshold value for the particular factor and began affecting the population densities of the soil Acari. The soil water content in this pasture soil for the period September 1962 to September 1963, varied between 2 % and 13 %, with an average of 7 %, and this must have been below the threshold value. LOOTS & RYKE (1966) found that increases in soil moisture content were accompanied by increases in the mite populations and decreases in soil content by decreases in the population numbers. In such a delicately balanced link up such as this, where the Acari will increase in population density as soon as the soil moisture content only becomes slightly more favourable, it is to be expected that they will have their maximum population densities at the same time as the soil moisture content reaches a maximum, i. e. in the summer months at the peak of the rainfall season, and the minimum population density during early spring when the soil moisture content is at a minimum. In the *Themeda-Elyonurus* pasture soil, environment and not inheritance, therefore, determines the population density seasonal variation pattern.

In the kikuyu pasture soil, which has a much denser vegetation cover than the *Themeda-Elyonurus* pasture soil OLIVIER & RYKE (1967) found the mean of the soil moisture to be 19.8 % in the sampling plot. The seasonal population density variation pattern of the Acari was found to have winter maxima and spring minima. Attempts to correlate population density changes with water content changes succeeded sometimes and at other times failed, apparently without reason. The present authors believe that in this habitat the soil water content factor is mostly above its affecting threshhold value so that the seasonal population density variation pattern is genetically determined, and is probably only sometimes affected by the environment. Because the pattern in this habitat is genetically determined, as also the one in the forest soils, the Acari in these two widely different habitats have their population density maxima and minima at the same times.

Further evidence in favour of this interpretation of events in the forest and pasture soils is the following:

In the favourable habitats such as the forest soil, population densities are very high, but in the habitats with extremes the population densities are quantitatively and qualitatively poorer. An increase in the organic material content of a soil causes an increase in the moisture holding capacity of the soil. There appears to be a tendency for soils with a high organic content to have a winter peak pattern for the soil Acari, and the soils extremely low in organic material content to have population densities varying with climatic changes in the soil.

The above-mentioned assumptions and postulations are offered as a tentative explanation for some of the otherwise seemingly meaningless phenomena which have been noticed in South African forest and pasture soils in connection with the population densities of mites. More information on similar and dissimilar habitats is, however, necessary for proof or rejection of the theory and also experimental evidence as to how the population densities of mites will vary under artificial and controlled conditions.

5.5. PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL AND THE MITE POPULATION STRUCTURE

HAARLOV (1955) found an agreement between the vertical distribution of mites and the size of cavities in the soil. Soil particle size affects the size of soil cavities and will presumably, therefore, also affect the mites. In practice this effect is seen in that large and small mites live in the surface layers of the soil where the cavities and soil particles are large, whereas only small mites penetrate into the deeper layers where both the cavities and the soil particle sizes are smaller. KÜHNELT (1961) states that uniformly wet soils, provided the subsoil does not consist of sand or heavy clay, contain a characteristic fauna. Here apparently the subsoil particle size affects the amount of water in the soil layers above it and in consequence, the other soil factors, pF values etc., which are dependent on the amount of water present in the soil.

In the Magoebaskloof forest soils two species of Mesostigmata, viz. *Gamasellus* sp. (M 45) and *Asca aethiopica* were frequently found at all the collecting stations except station F. Station F differs from the other collecting stations in that, (a) there is a higher percentage of clay than at the other stations (table 1), (b) there are more free calcium ions available in the soil; (c) the pH is less acid than at the other stations, and (d) the distribution

of organic material corresponds to that of a mor soil. It is not possible to isolate the effects of these factors in the Magoebaskloof forest soils and therefore all these factors must be stated as possibly affecting the distribution of the above-mentioned two species of Mesostigmata.

It is not possible in this work to estimate the ecological effect of factors such as exchangeable ions and pH values on soil organisms and in particular on the soil Acari, but when more information becomes available on other habitats in South Africa, such as various kinds of grass veld, salt pans, mud banks, sea shores etc., the ecological effects of these factors, as well as those that have been briefly discussed, might be more clearly understood.

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